AD-A126 057 EUROPEAN SCIENTIFIC NOTES VOLUME 36 NUMBER 12(U) OFFICE 1/1
OF NAVAL RESEARCH LONDON (ENGLAND)
R L CAROVILLANO ET AL. 31 DEC 82 ESN-36-12

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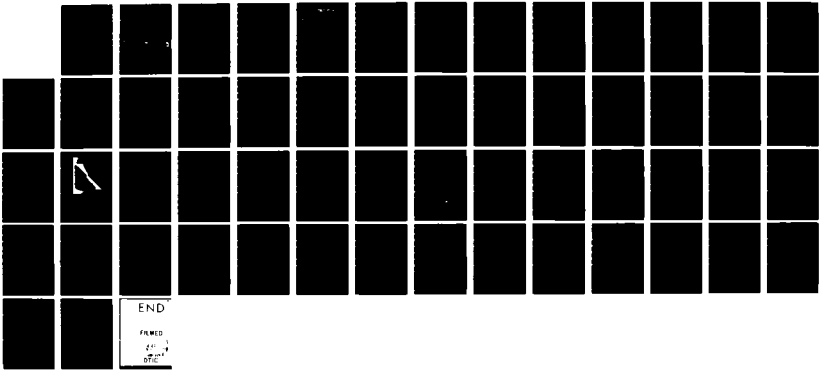

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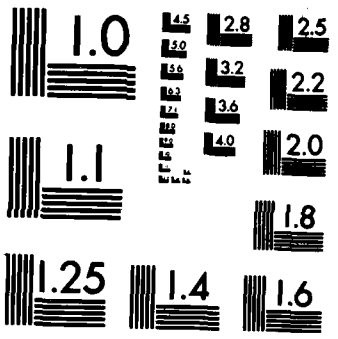

OFFICE OF NAVAL RESEARCH
LONDON

EUROPEAN SCIENTIFIC NOTES

ESN 36-12

31 December 1982

Distributed by the
Office of Naval Research Branch Office,
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 36-12	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* EUROPEAN SCIENTIFIC NOTES		5. TYPE OF REPORT & PERIOD COVERED Monthly December 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Office of Naval Research, Branch Office London Box 39 FPO NY 09510		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 31 December 1982 13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

European Scientific Notes (ESN) is a monthly publication with brief articles on recent developments in European Scientific research. The publication is not intended to be part of the scientific literature. The value of ESN articles to Americans is to call attention to current developments in European science and technology and to the institutions and people responsible for these efforts. ESN authors are primarily ONRL staff members. Occasionally articles are prepared by or in cooperation with staff members of the

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ESN 36-12 (1982)

EUROPEAN SCIENTIFIC NOTES OFFICE OF NAVAL RESEARCH LONDON

edited by Robert L. Carovillano, Larry E. Shaffer, and Francis A. Richards

31 December 1982 Volume 36, No. 12

Articles presented in this report follow:

NEWS & NOTES

European Scientific Notes is a Class I Periodical prepared and distributed by the Office of Naval Research London in accordance with NAVEXOS-P-35.

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BEHAVIORAL SCIENCES

ARTIFICIAL SKIN SENSORS IN ROBOTS AND BIOLOGY

An important element in any device that imitates or aids human performance is the sensor system. The general requirements for any given sensor application are usually well known. To drive a wheel chair, for example, reliable sensors are needed to respond to the stop, go, turn, and speed commands. Similarly, a robot arm has to grasp, manipulate, and release work pieces in three-dimensional space. All very neat.

Yet it is surprisingly difficult to provide a good wheelchair for handicapped people or to design an effective robot arm for complex manipulations. What seem to be geometrically simple tasks really may be quite complex--partly because when they are done by human performers, certain features (smoothness, ability to make slight but critical adjustments, avoidance of catastrophe or overload) are automatically added to the net requirements of the task. There are sensor projects all over the world to explore the conversion of physical data into signals that would be effective aids to semi-automatic equipment.

One of the more interesting sensor efforts is the "peau artificielle" (artificial skin) project at the Laboratoire d'Automatique et d'Analyse des Systemes, Toulouse 31400, France. As one of the CNRS (French national) labs, Toulouse has many people working in automatic systems. M. Jean Clot, the engineer in charge of "new sensor" work, has seen the Toulouse program grow from a small sensor trial into several major applications.

Artificial skin in robotics is basically a thin layer of material in which miniature electrodes are imbedded. The surface is often metallized for protection against mechanical damage. A deformation of the surface produces resistance changes in the barrier material, and these in turn are transformed, amplified, and fed into a computer. Parameterization and sensitivity will depend, of course, on many variables, such as the density of the revetment and the spacing of electrodes. The Toulouse workers have built practical skin arrangements with interelectrode packing distance of about 2.5 μm. Such skins can have a minimum deformation sensitivity of 50 g/cm^2 and can accept loads up to some dozens of kilograms per square centimeter. The data readouts are sufficiently linear over the ranges of interest to use linearity assumptions for practical applications.

In a practical application, the protective cover of the artificial skin is metallized, with the main skin made of sheet rubber, polybutadiene, polyisoprene, or other kinds of foams or fabrics. A pressure stimulus at any point on the skin will produce three readouts: the coordinates of excitation, the estimated pressure P(±10%), and the net electrical characteristics at each excited point. There were, of course, many engineering problems that had to be faced in order to tie the skin readouts into a computer, but these seem to have been solved by the Toulouse staff over the past few years.

The first application of the artificial skin at Toulouse involved an artificial hand. Named Spartacus, the project was a joint one with the Institut de Pupin in Belgrade, Yugoslavia. An ordinary-looking mechanical hand with controllable finger joints was fitted with artificial skin. As shown in Figure 1, each finger had three pieces of skin pad attached to the palm side, and the thumb and palm had two pieces. Early trials showed that reliable "spot" readouts could be obtained with a hand fitted in this way.

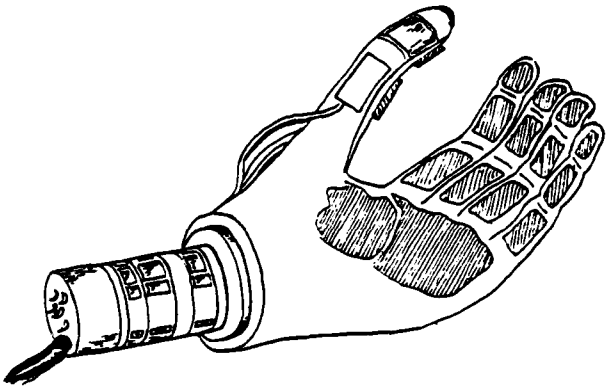

Figure 1. Artificial skin on artificial hand.

Far more interesting than the simple spot-pressure readout was the possibility of really complex control through a computer-aided artificial-skin system. Suppose the hand is to hold a packet of cigarettes. To prevent crushing the contents, a very light pressure is required; the instantaneous skin readouts could be adequate stimuli for adjusting all pressures to low (and approximately equal) levels.

However, if some external force attempts to take the cigarette pack out of the hand, then the "glissement," or slipping, would be noticed by the system, which would apply enough additional pressure to hold the pack. Such decision capabilities obviously need much more engineering than a simple, preset holding command. To handle such complexities, the basic pressure signal (call it U_B) was supplemented with an adaptation signal (U_A). The U_B output follows the exterior pressure rather closely, while U_A adjusts itself over time, perhaps to some standard or holding value that fits the circumstances at the moment.

A sufficient disturbance, such as pulling the cigarette pack away from the fingers, then

activates new movement in the digit-palm actuators. The overall detection logic was successfully tested on several objects. Medical applications of the techniques developed at Toulouse are now under way in several French hospitals. There are many software problems involved in such systems, and reportedly the artificial skin capabilities furnish some useful planning limits to the software production people.

One amusing application of artificial skin may make it easier to play musical instruments. In November 1982, the Toulouse Laboratoire painted a standard-sized piano keyboard on a 2-ft piece of skin and connected the sensors to a small electronic organ. This demonstration was part of the Innovation Exposition, or technical fair, at Toulouse. The player activates a "key" on the organ by lightly touching the painted key on the flat skin. Trained piano players quickly adapt to the "superlight" digital keyboard, and play very much as on a regular piano--except that the lightest touch is sufficient, and "idle" fingers cannot just rest on the keyboard.

Glissandi and rapid arpeggios can be played easily and exactly with a skin keyboard. In fact, one can envision wind instruments being played by means of such a keyboard, since some woodwind instruments are notoriously bad from the standpoint of ergonomics design. To hit a low B♭ or A on a baritone saxophone, for example, each of the two little fingers must press down large pads that are linked to several feet of clanking brass rods, while the stronger and faster first and middle fingers are merely depressing a single smaller pad right under the finger. As a result, the lower notes are played with much less facility.

If the artificial-skin sensor concept could respond fast enough, then all ranges of "heavy" woodwind instruments could be played with equal facility, which would be a remarkable boon to musicians. An Australian instrument--the Fairlight Moog, used by Stevie Wonder and a few others--is played in regular keyboard fashion, and also by stroking or rocking the keys in several ways. Rocking causes the pitch of a note to waver around a central frequency; the downward impulse of a key press can control the sharpness of the leading edge of the tone and can also affect the decay characteristics. The promise of aids like artificial skin to make mechanically difficult passages easier to play, along with special multi-feel keys to alter tone and timbre, should be truly exciting for the musician.

The Toulouse researchers have developed several extensions of artificial skin to robotic parts handling. One version has four pieces of artificial skin on each side of a pair of holding jaws; the sensors measure orthogonal pressure, pulling force or traction, and torque "gliding" forces. Measurements of gliding forces, for instance, are useful when the robot has to screw together parts up to some predetermined or computed torque. Another gadget is designed to determine the form of an object by "feeling" and recording the contours. As all robotics people know, some physically simple problems in parts assembly remain difficult; "soft" handling is often necessary to start threading a screw into a tapped work piece because rigid location would cause breakage. Toulouse has several ways of managing that problem. It should be added that each way has its advantages and drawbacks, and that there is still no standard approach to the "near-miss" location problem.

Pressure sensors installed in artificial skin have also been assembled into special devices for underwater measurements and for recognition of objects in deep water by their imprint on a sensor matrix. One practical application is the underwater joining of large pipes; reportedly, systems derived from the Toulouse sensor work are now used by the French petroleum industry for precision pipe work.

The most surprising extension of sensor technology, however, involves immersing miniature sensors in a biological growth medium. A recent Ph.D. thesis by Josep Salvany at Paul Sabatier Univ. in Toulouse showed that the CNRS "capteur" (sensor) technology can be directly useful for tracking biological growth phenomena.

Escherichia coli is a standard bacterium for biological growth studies. It is aerobic and can be grown easily in relatively simple laboratory media. The organism's growth conditions have been intensively studied, so a new experimental setup can be "calibrated" against known growth curves. Also, E. coli responses to bactericidal agents are well documented. For such reasons, the Toulouse researchers elected to put microsensors into growing milieus and to record the electrical signals over time.

Under ideal milieu conditions, organisms that double at each generation produce a fairly exponential growth curve. For a small starter set of E. coli, which doubles about every 20 minutes, the growth curve becomes very steep by the third or fourth hour, and remains so until milieu conditions hinder steady doubling. Optical turbidity increases are usually well correlated with cell counts. Eventually, at about 10 or 15 hours in conventional setups, a plateau is reached, after which the visible cell count begins a slow deceleration and thereafter follows a relatively slow exponential decline.

The rates of growth and decline are quite dependent on variables such as temperature, radiation, and food in the medium; for instance, the total number of live organisms is linear with concentrations of sugar up to 6 mg/ml. General growth inhibiting substances such as the heavy metals interfere with the cellular metabolic chain. There are also many antibacterial agents that are specific in their effects; the antibiotics affect highly localized sites such as the cytoplasmic membranes or the ribosomes. As one example, an antibiotic effective at the membrane may increase the permeability of the membrane and thus

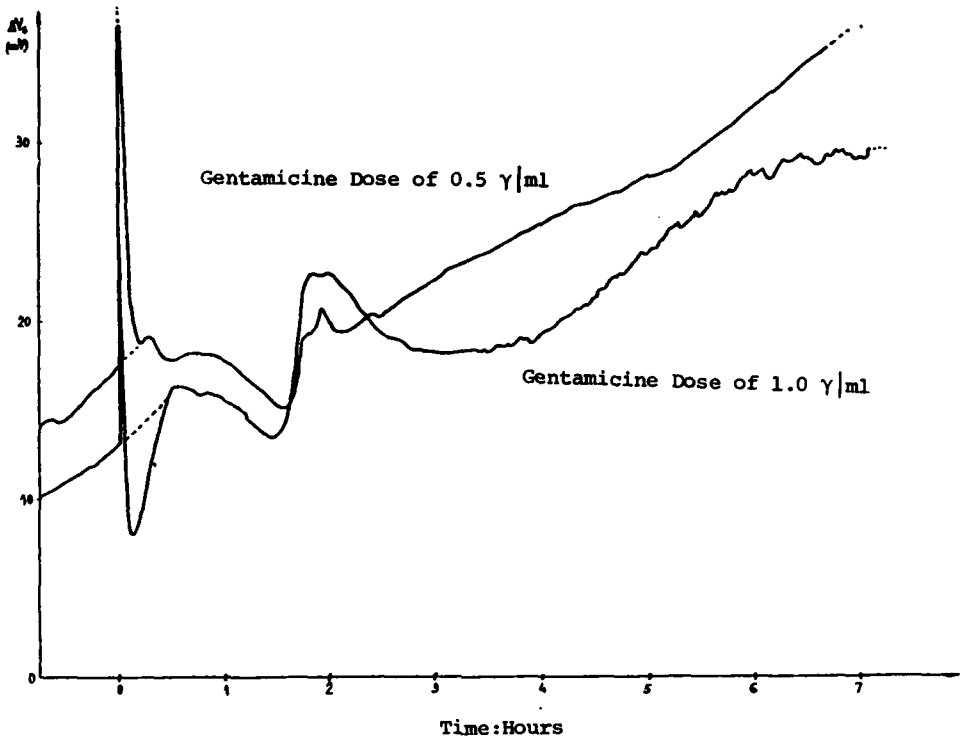

Figure 2. Superimposed curves showing impact of the antibiotic gentamicine on E. coli growth.

produce, to the detriment of the organism, a leakage of intercellular material of low molecular weight.

The experimental question for the Toulouse researchers was whether the conductivity of a biological culture medium, as measured by an electrical sensor, was related to organism growth in the medium. After many trials, a special electrode 8-mm wide was developed; the device had alternative electrodes packed into the sensor at an interelectrode distance of 50 μm. Since the bacteria themselves are on the order of a micrometer long, the scale of the electrical leads involved was a compromise between the stability of the cellular organisms and the sensitivity of the measuring device.

With temperature in the growth medium rigorously controlled at 37°C, the delta voltage measurements matched rather well such correlated parameters as optical turbidity and pH. This result can be taken as a validation of the whole Toulouse sensor system. There were even some indications that the voltage measurements contained more detailed information than did the usual organism-count curves. Many interesting curves were obtained when the antibiotic gentamicine was added to the mix. The detailed voltage responses to two levels of antibiotic are shown in Figure 2.

The many trials and calibrations that have been run at Toulouse prove the good reproducibility of the electrical aspects of a medium with growing bacteria. Because the electrical measures are so sensitive and reliable, they may be useful in understanding the fine structure of certain events, such as those occurring at the moment of injection of antibiotic material. It is remarkable that a project that originated in practical prosthesis and robotic design now finds itself immersed in biological growth studies.

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ONR London

BIOLOGICAL SCIENCES

HYPERBARIC EVACUATION SEMINAR

A saturation diver on a North Sea oil platform has just completed several days of work at a depth of 150 m and settles down in one of the deck decompression chambers (DDC) to wait out the 5 days of decompression to surface pressure. He is suddenly informed

that an emergency (e.g., fire, bad weather, collision) has made it necessary to abandon the platform.

The diver is faced with two disagreeable choices. On one hand, a rapid return to sea level pressure would mean certain and painful death. On the other hand, staying inside the pressure chamber as it goes down with the platform almost certainly will result in damage to the chamber's life support systems and lead to a slow but sure death. However unlikely the scenario may seem, some would argue that it is only a matter of time until such a tragedy occurs.

The Society for Underwater Technology (SUT) sponsored a seminar on hyperbaric evacuation (HE) on 22 September 1982 at the Aberdeen Skean Dhu Airport Hotel. Representatives from government and industry were present to discuss the many ramifications of HE. The two countries most involved in this field are Norway and the UK.

In 1978, the Norwegian Petroleum Directorate (NPD) ordered oil drilling operations in its jurisdiction to provide a means of escape to the diver who might be locked in a pressure chamber at the time of an emergency. The reasoning was that all employees should have at least one avenue of escape. Mr. Rosengren from NPD emphasized that the directorate has deliberately avoided making specific requirements because to do so would limit innovative approaches to the problem.

There were objections to the requirement for HE in 1978, and there are still many protests. Industry representatives feel that the absence of specific requirements has allowed less scrupulous diving contractors to get by with cosmetic compliance. The argument is that in a real emergency many current schemes for HE would be unreliable and, in some cases, could actually increase the risk to the diver. There is even the argument that HE may not be needed at all. However, given that emergencies will happen and given that human lives are at stake, no one should really want to ignore the potential need for HE.

The ongoing controversy suggests possible options. How do you provide for HE? Do you transfer the divers from a DDC to another pressure chamber which is then removed from the platform; or do you design a DDC which is detachable from the platform? With the divers in a detachable chamber, do you remove the contraption by air, or do you launch it into the sea? If by sea, what do you do if the platform tilt makes normal launch impossible? With the dangerous weather conditions in the North Sea, would it be safer to attempt an air lift of the chamber? Would air evacuation of a chamber be more or less dangerous than launching a chamber into the sea?

Amidst all the arguments and questions, a few definite observations can be made. First, there is no medical means of making a person less susceptible to fatal decompression sickness. As Dr. Cox of Phillips Petroleum Ltd. said, "we have no magic pill." Cox noted, however, that faster yet safe emergency decompression schedules might be developed; these would reduce the amount of time that a diver would be at risk.

Second, Mr. Clarke of Wharton Williams Ltd. presented data which showed that once divers were in a hyperbaric lifeboat (HL), keeping them saturated would require fewer supplies than attempting to decompress them. Representatives of Houlder Offshore Ltd. presented their design of an HL with all the supplies and controls inside the chamber. They also showed that state-of-the-art insulating materials allow adequate control of the thermal environment.

Finally, Dr. Pasche of the N wegian Underwater Technology Center (NU ; reported on an evaluation of an HL rrowed from the STENA line. The HL can ac nodate up to 12 divers. NUTEC investigator owed that it was possible to start with the n the quay and have it hooked up to one their DDCs within 2 hours. Further studi ed that with 12 people on board, hyp rmia could be a problem. This was not anticipated before the evaluation; cooling equipment has since been fitted to the HL.

Clearly the problem of HE is not yet solved. The talks and discussions at the seminar highlighted the many problems associated with HE. More investigation in the field can only lead to improvements and decrease the risks faced by divers.

A.R. Manalaysay

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CHEMISTRY

FOURTEENTH EUROPHYSICS CONFERENCE ON MACROMOLECULAR PHYSICS--POLYMER CRYSTALS: STRUCTURE AND MORPHOLOGY

The 14th Europhysics Conference on Macromolecular Physics concentrated on four areas: advances in methods of sample preparation and examination, crystal perfection and defects, the morphology of polymers formed from the unperturbed melt, and the morphology of oriented systems.

The conference took place from 21 through 24 September 1982 at Vilafranca del Penedes near Barcelona, Spain, under the chairmanship of Professor F.J. Baltá Calleja, Instituto de Estructura de la Material, Madrid. There were about 100 participants from 16 countries, including eight from the US, seven of whom presented lectures. There were 10 invited lectures, 24 contributed papers, and 26

posters. The meeting was well organized and had no concurrent sessions.

Sample Preparation and Examination

The opening lecture was presented by Andrew Keller, (Univ. of Bristol) on "Chain Folding: Current Status in Polymer Crystallization and Structure." The most extraordinary and basic feature of many crystalline lamellae is that the polymer chains are folded up and down repeatedly in a direction perpendicular to the lamellar surface, a fact that was discovered in Keller's laboratory 25 years ago. Keller addressed the basic issue of the primary fold length and its dependence on the temperature of crystallization. The dependence is not well known, particularly for crystallization from the melt as opposed to solution. The melt, however, is more relevant technologically.

The reason for the lack of knowledge about melt systems is that the polymer chains refold after formation. The observed chain lengths therefore do not correspond to those of the newly born crystals. Keller described a number of experiments aimed at estimating the primary fold length values. The range of temperatures over which crystallization was conducted was also extended for both melts and solution. Crystal growth rates could be measured at previously unattainable supercooling conditions. Extremely fast growth rates (>2 m/s) were observed. Polyethylene was used as the model polymer for the studies.

The second invited lecture--by E.W. Fischer (Univ. of Mainz)--reviewed the application of neutron scattering to mixtures of deuterated and undeuterated molecules of crystalline polymers and discussed some new work. Small angle studies yield the radii of gyration, which change very little with crystallization. Intermediate scattering angles mainly give the average distance between the stems, while wide angles give space correlations. The subject itself is still highly controversial, as is the nature of the fold surface.

Fischer emphasized the importance of the crystallization conditions, which can grossly alter the scattering effects. There was, in his opinion, no indication of privileged adjacent re-entry in the folds for melt-crystallized polymers. New work with rather monodisperse polyethylene oxide confirmed the conclusions, but higher crystallization temperatures appeared to lead to more adjacent re-entry.

D.M. Sadler, (Univ. of Bristol) also discussed neutron scattering from solution-grown polyethylene crystals and, to a lesser extent, from the melt with high scattering angles to provide increased resolution. The results indicated runs of adjacent re-entries separated by gaps of nonadjacency. Stem adjacency was much more pronounced with solution-grown crystals, in agreement with Fischer's conclusions. Sadler discussed the development of curved crystal facets known to occur at high crystallization temperatures. The concept of equilibrium surface roughness, well known in the growth of simple substances, was invoked. If correct, it would open up an important new approach to polymer crystallization theory. J.M. Guenet, Centre de Recherches sur les Macromolécules (CRM, Strasbourg), discussed neutron scattering results on bulk crystallized isotactic polystyrene. There was no isotopic segregation; crystallization close to the melting point could be followed. Preponderantly adjacent re-entry, also in solution-crystallized material, was indicated with more random re-entry at lower crystallization temperatures.

J.C. Wittman and B. Lotz (CRM, Strasbourg) presented an ingenious new decoration technique using vaporized polyethylene itself as the agent. Contrary to gold decoration, for example, local orientations at the outer surface of the substrate material could be revealed. The method is still qualitative but promises to be of considerable value.

D.C. Bassett (Univ. of Reading) presented structure studies on polyethylene using potassium permanganate in sulfuric acid as a selective etching agent. Electron microscopy of replicas of the etched surfaces revealed the intricacies of the lamellar details of melt-crystallized polyolefins. Well-defined internal periodicities were shown; these were transverse to the spherulitic radii based on the repetitive segregation of shorter and branched molecules to specific structural locations. The result is varying structure-dependent properties from point to point within the samples. It was confirmed unequivocally that methyl branches alone are accommodated within the crystal lattice.

A. Pelzbauer (Czechoslovak Academy of Science) discussed various electron microscopy methods, synchroton radiation techniques were reviewed by H.G. Zachmann (Univ. of Hamburg), and high resolution magic angle and other nuclear magnetic resonance (NMR) methods were determined by W. Gronski and H.J. Cantow (Univ. of Freiburg) and R. Kitamaru (Univ. of Kyoto).

Crystal Perfection and Defects

B. Lotz and J.C. Wittman presented a paper on the epitaxial crystallization of polyethylene, polypropylene linear polyesters, and polybutene-1 on various low molecular weight substrates, including napthalene, potassium hydrogen phthalate, and benzoic acid. The epitaxial relationships between the polymer and the low molecular weight substrates could well provide a clue not only to the substrates' value as nucleating agents but also to the crystallization and morphology of polymers. The work clearly has important practical and technological implications.

E. Martuscelli (Institute of Research on the Technology of Polymers and Rheology, Naples) discussed the effect of chemical defects on the morphology of crystalline polymers. Such defects could include comonomers, stereoisomer branches, and chain ends and can be

introduced fortuitously during the synthesis or by design. Considerable experimental data were presented on the effects of composition variations on the morphology, crystalline structure, melting, and thermal and annealing behavior. Profound changes were shown to be brought about by the introduction of such "defects."

R. Hoseman (Bundesanstalt für Materialprüfung, Berlin) presented his paracrystallinity approach to an understanding of the structure and properties of polyethylene. His approach to solid state physics, crystallography, and to colloidal materials in general is quite different in that it considers such materials as built up of extremely small microcrystals. A discussion of paracrystalline disorder in polymers was presented by R. Wilke (Univ. of Ulm). The microstructure of melt-crystallized polymer systems was discussed by H.G. Kilian (Univ. of Ulm) using a paracrystalline model and the linear theory of paracrystals. Some of the merits of the approaches have been recognized, but the subject remains quite controversial.

B.J. Jungnickel (Deutsches Kunstoff Institut, Darmstadt) reviewed the crosslinking of linear polyethylene with high energy radiation. High molecular weight linear polyethylene was irradiated with fast electrons in both molten and solid states. With the melt-irradiated samples, lattice disorders of the first kind were found on crystallization; their density showed a distinct maximum at about 25 Mrads. It was assumed that folded crystals formed at lower doses and micellar ones at higher doses. The morphology and crystallinity of samples irradiated in the solid state did not change appreciably. The recrystallization was found to be essentially independent of the total dose.

D.H. Reneker (National Bureau of Standards [NBS], Washington) presented his unique approach to defects that can arise in polyethylene fibers. He suggested that twists in the polymer chains can result from the crystallization and subsequent deformation. Various kinds of defects were defined and together with folds, chain ends, and edge and screw dislocations can provide a basis for interpreting many properties of solid polyethylene.

Morphology and Crystallization From the Unperturbed Melt

The session was opened by L. Mandelkern (Florida State Univ.), who reviewed the morphology of melt-crystallized polymers. The two levels of structure (molecular or chain) of the lamellae and their organization into superstructures were discussed in some detail. Many different thermodynamic and spectroscopic studies together with small-angle neutron scattering (SANS) studies indicated that regularly folded chains are not favored. Studies of high density polyethylene using $ClSO_3$ plus electron microscopy and calorimetric methods were reported by G. Kanig (BASF, Ludwigshafen). Kanig's interpretation supported the switchboard model. J.H. Magill (Univ. of Pittsburgh) reviewed his extensive work on the polysiloxanes, both homopolymers and block copolymers. New information on chain folding with such unique materials is revealed by this paradigm. A.J. Kovacs (CRM, Strasbourg) reviewed his extensive work on the crystallization from the melt of highly monodisperse, low-molecular-weight polyethylene oxides. Using a combination of seeding, decoration, and other techniques, Kovacs could follow the rate of growth of single crystals as a function of temperature with great accuracy. The growth rate decreases with increasing temperature, as his work shows with steps in the plots of log rate versus temperature. The steps correspond to the number of folds and finally, at the highest temperature, to extended chain crystals. The extended crystals are the most stable form. These and other data show that chain folding is kinetically controlled and that growth proceeds by coherent surface nucleation. Kovacs' work, like that of Magill, should have considerable relevance to the phenomenon of chain-folding in general.

Two theoretical papers were presented. J.D. Hoffman (NBS, Washington) spoke about new work on the role of reptation in describing the rates of crystallization of polyethylene from the melt. The conclusions were that the long chain molecules can move rapidly enough in the melt to account for the observed lateral growth rate of the crystals while adhering to the chain folding mechanism. J.J. Point (Univ. of Mons, Belgium) presented a significant theoretical paper on the kinetics of crystal growth. The presentation and the theory were complex, and the published paper will be awaited with keen anticipation.

Morphology of Oriented Systems

I. Ward (Univ. of Leeds) reviewed his extensive and pioneering work on the formation, structure, and properties of highly oriented polymers, mainly linear polyethylene (LPE). His techniques involve the drawing of continuous filaments in a hot oil bath, by wire-type drawing through a die and by hydrostatic extrusion, i.e., pushing and drawing. Draw ratios of 30+ are necessary to achieve the ultra-high modulus materials. The possible draw ratio appears to decrease with increasing molecular weight, while the modulus is essentially independent of molecular weight. The creep and permanent flow of such fibers are reduced by a modest degree of radiation before extrusion. The model suggested by Ward's studies is that the two-phase structure of low draw LPE is retained, but there is a considerable increase in the average crystal length because the crystalline blocks are linked by randomly placed crystalline bridges. Considerable data were presented describing the morphology and the mechanical and other properties of highly drawn polyethylene. Finally, results obtained with other highly

drawn fibers, including ethylene copolymers, polyethylene terephthalate, and polyoxymethylene, were presented.

A. Peterlin (NBS, Washington) presented his model of the drawing process, the significant difference from the Ward model being the existence of distinct microfibrils pulled out of some of the crystalline blocks to form tie molecules. The importance of the use of diffusivity measurements as a diagnostic tool for understanding the structure of the noncrystalline regions was emphasized. The models of Ward and Peterlin dealing with the drawing of solid polymers are well established and described in the literature.

There were three contributions about drawing processes that depend on a solvent at some stage. All three cases involve gel formation and to some extent shish-kebab-type crystal formation. Papers were given by P.F. van Hutten and A.J. Pennings (Univ. of Groningen), P.J. Lemstra (Dutch State Mines, Geleen), and a poster presentation was given by P.J. Barham et al. (Univ. of Bristol). P.F. van Hutten discussed the preparation of highly oriented high molecular weight polyethylene fibers from solution. The preparations were accompanied by the formation of shish-kebab structures. The fibers were formed by high speed stirring of solutions, by surface growth in a Couette type instrument, and by a new gel spinning technique. The spinning involved cooling the solution with stirring and also involved the formation of shish-kebab structures. Chemically linked gels can also be used. The importance of porosity of the fibers at the early stages was stressed.

Lehmstra et al. recognized the essential importance of the gel state for fiber drawing. They set out to produce gels in the most practical manner for subsequent fiber drawing. They noticed no shish-kebab formation and merely cooled down solutions of very high molecular weight polyethylene. As long as the solution gelled on cooling and the gels were extensible, the purpose of producing high modulus and tenacity was served. Their process is now leading to small scale production at Geleen. Scientifically, Lehmstra considers chain entanglements to be the principal initial gelation mechanism. The high draw ratios possible with such very high molecular weight polyethylenes in solution compared with the melt were ascribed to the lower degree of entanglements. The more dilute the initial polymer solution, the higher the draw ratio that could be achieved.

P.J. Barham, K.A. Narh, and A. Keller (Univ. of Bristol) showed that solutions of high molecular weight polyethylene stirred at high temperatures formed gels when cooled in the quiescent state. Similar unstirred solutions, however, did not form gels on cooling. Barham, Narth, and Keller suggested that small crystals formed the junction points of the gels from the stirred solutions. Shish-kebabs may result from gel stretching, but whether they are necessary for high modulus fiber formation is still a subject of controversy between the Groningen and Geleen groups. The Bristol group considers that the flow induced crystallization is the source not only of gel formation but also of subsequently formed shish-kebab structures. In this respect the Bristol group takes a somewhat intermediate position. In any case, solution processing involving gels is a highly promising new approach to the formation of high modulus, high tenacity fibers.

Other papers concerned with oriented polymers were presented by G.S.Y. Yeh (Univ. of Michigan) on the morphology and thermal behavior of shear-crystallized polyethylene, and R.S. Stein (Univ. of Massachusetts) on the use of optical and x-ray scattering and diffraction for the study of morphology and orientation of polymers.

M. Kryszewski (Polish Academy of Sciences, Lodz) gave an important paper on the influence of crystallinity and morphology of doped polyacetylene on its electrical properties. It has been shown that the structure is not fibrillar but consists of lamellar aggregates with doped and undoped regions. Kryszewski described the preparation of a new class of conducting polymers consisting of an inert polymer matrix, poly (bisphenol A carbonate), containing reticulated and interconnected microcrystalline charge transfer complexes. The complexes were introduced by casting a mixture of the complex between TTT (tetrathiotetracene and TCNQ 7,7', 8,8' tetracyanoquinodimethane) and the polycarbonate in, for example, o-chlorobenzene at about 150°C. One percent of the TTT-TCNQ complex yields a film with a dark conductivity of 0.1 $(\Omega\text{-cm})^{-1}$. The conductivity is only slightly temperature dependent and has not yet been optimized.

It has only been possible to do justice to about one-half of the papers and posters presented. The remaining contributions were of high quality and the conference was one of the best and most complete ever to be organized on the subject.

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COMPUTER SCIENCES

A DATA FLOW COMPUTER AT THE UNIV. OF MANCHESTER

The Data Flow Research Group at Manchester Univ. has been investigating a data-driven architecture since 1976. A prototype system has been constructed with funding provided by the Science and Engineering Research Council (SERC) of Great Britain. The system was

described to the author by Dr. John Gurd, one of the principal architects of the system, in a recent meeting at the Univ. of Manchester.

Because of the increasing demand for very high speed computers, research on the organization of data-driven systems continues at many institutions. The parallel type of design has been implemented in systems that have been built over the last decade. A good example is the Cray system, designed by Seymour Cray and built by Cray Research Corporation. In a conventional parallel computer, the design allows for a number of processors operating in parallel on different data sets but with the same operations being performed.

The parallel design fits some problems quite well, but certainly not all. The rigidity of the machine size and shape in general allows only partial mapping of the problem onto the machine. The Cray computer in theory can calculate at the rate of 150 million floating point instructions per second. This can be achieved only if the parallelism in the problem precisely fits the machine design. In pratice, an average speed of 20 million floating point instructions per second is more common. A computer of such architecture is sometimes called a single instruction, multiple data (SIMD) machine.

Another architecture is the multiple instruction, multiple data (MIMD) system. One approach is to have the processors that operate in parallel share the memory of the system, as Carnegie-Mellon Univ. has done. However, one difficulty is the increasing competition for memory access with the increase in the system's number of parallel processors.

Another approach is to arrange for message passing via a crossbar from the parallel processors to multiple store modules. However, a major difficulty arises in both the shared memory and message passing approaches--that of partitioning the problem to be solved.

A somewhat unconventional approach to machine organization is that of data flow, which is the approach taken at Univ. of Manchester. A data flow machine contains a number of independent processors, each of which receives a stream of data tagged with destination and control information. The processor sorts out the data due to be combined by matching tags. On finding a match, the appropriate calculation is performed and one or more new data packages (tokens) tagged with their destination are sent out. The processors are connected through a communications network.

The basic structure of the Manchester data flow machine incorporates a processing unit, a token queue, a matching unit, a node store and a host computer to provide peripheral control and storage. The units are connected in a pipelined ring around which the tokens flow. The tokens carry data, a label, and a destination node address, i.e., the address of the unit in which processing will take place. A token produced by a node exits from the processing unit where the execution of several node operations may be proceeding concurrently. Upon arrival at the token queue the token is stored temporarily. The matching unit collects pairs of tokens with the same destination node address and label. If no partner is found, the token is written in the store to await a partner. A pair of matched tokens leaving the matching unit addresses the node store to obtain the destination node operation and the subsequent destinations of its outputs. The package is then passed to the processing unit for execution.

Architecture and Technology

The matching unit is the critical element of the system. The rate at which an associative match between destination and label fields of the token can be achieved governs the maximum data rates around the ring. The processing unit at Manchester contains 20 parallel processors, the minimum needed to match the ring data rate for optimum performance. The ring also has pipeline parallelism as the operation in each unit is overlapped.

The basic pipeline beat is 200 nanoseconds. Each unit in the pipeline is internally synchronous, but communicates with other units using an asynchronous protocol. Each unit requires one pipeline stage for operation and one for communication.

Data Formats

Although a 64-bit data width might have been preferable for solving large scientific problems, a 32-bit data width was chosen because of constraints such as cost, connector density, and available printed circuit boards. The token size is 96 bits--32 bits for data, 36-bit label field, 18-bit destination field and 10 bits for information and control.

Units of the Ring

A Digital Equipment Corporation (DEC) LSI-11 is the host computer and provides peripheral control and storage. The token queue is a first-in, first-out buffer using static random access memory with pointers requiring that read and write be performed in 200 nanoseconds. The queue at Manchester has a maximum capacity of 16K tokens.

The token matching unit must provide storage for 16K tokens in the prototype system. To reduce costs, the system uses a hardware hashing technique to simulate the function rather than a true content-addressable memory. The hashing mechanism is a separate pipeline stage with input and output buffers. In the main store, an unsuccessful match takes 320 nanoseconds; a successful one requires 240 nanoseconds.

The node store is made up of a segment table containing 64 entries and a main store of 16K entries. Six bits of the destination specify the segment address, and the remaining 12 bits define an offset within the segment. The segmented structure provides independent

programs protection against invasion by tokens from other programs.

The processing elements in the processing unit have writable microprogram storage so that instruction set changes can be made readily . The processing unit has two pipeline stages. One handles simple label operations and the gathering of performance statistics; the other is a parallel array of processing elements. Each element of this array performs 24-bit-integer, or 32-bit-floating-point arithmetic. The microinstruction cycle time of each processor is 200 nanoseconds, and macroinstructions include between 5 and 50 microinstructions, with an average instruction time of about 6 microseconds. This requires 20 processors to match the input rate of one executable package every 300 nanoseconds.

Conclusions

With the present basic pipeline beat of 200 nanoseconds and the expected mix of inputs, executable packages should be available at a rate of one per 300 nanoseconds at the processing unit. This would result in an execution rate of 3.3 million instructions per second if the hardware can be used fully. Simulation studies show that a utilization rate of over 90% can be achieved if the problem has enough parallelism to fill the pipeline.

The pipeline beat could be reduced to 25 nanoseconds with the fastest available technology, and this would, in theory, result in an execution rate of more than 20 million instructions per second. However, the serial nature of the single ring would then become a limiting factor. Parallel rings could be used to take advantage of the faster technology.

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NATO WORKSHOP ON DISTRIBUTED SYSTEM DESIGN METHODOLOGY

A 4-day workshop on Distributed System Design Methodology was held at NATO Headquarters in Brussels from 18 through 22 October 1982. Participants came from Canada, Denmark, France, Germany, the Netherlands, UK, and the US. H.U. Steusloff, (Fraunhofer-Institut für Informations-und Daten Verarbeitung, Karlsruhe, Germany) served as chairman. Selected papers are summarized in this article.

Design of Distributed Data Bases

J.C. Chupin (CII Honeywell Bull Research Center, France) gave the opening paper on distributed information systems, which provided a framework for the first of four sessions. He discussed two fundamental approaches selected from various research prototypes. One consists of building a Distributed Data Base Management System (D-DBMS), including data description and data manipulation languages, and the other consists of developing Cooperative Transaction Processing Systems (C-TPS). The approaches differ in the way consistency is defined and in the degree of transparency offered to users.

The simplest configurations for D-DBMS are applicable only in environments where just one type of DBMS exists throughout the network. When dissimilar DBMSs are involved, a cooperative scheme must be considered. The goal is to provide global users a unified view of the collection of heterogeneous data that had originally been included in several possible dissimilar DBMSs.

In providing the data description, the global model must be at least as powerful as each participating model so that no loss of semantics occurs. The model must permit access to all existing data and must allow the creation of global semantic links between previously independent data. The designer of the global data base should be concerned with global semantics and with localization, while the data presented by local data base designers conform to the global scheme. In the relational data base model, the global view consists of creating new relations from existing ones. However, most prototypes seem to have stumbled over consistency of data while updating. As local consistency constraints have been defined independently, global constraints probably cannot be deduced from them easily. Conversely, a purely global constraint pertinent to the application logic cannot always be translated into a coherent set of local constraints. Perhaps an algorithmic approach to consistency would be more appropriate than one based on data description.

Relational algebra is helpful in data manipulation. After a global request has been issued, it can be decomposed into local relational requests to be executed on the proper sites. An adequate execution monitor is needed for remote execution, reception of partial results, and inter-site synchronization.

In C-TPS, an explicit global scheme is no longer required. The cooperation between local data bases is accomplished by dialogue between them. Cooperation between local transactions on different sites with transaction processing systems corresponds to global actions dictated by the application. A global transaction is started through the first local transaction that composes it. The initiator transaction plays a special role in the global process and materializes a global transaction.

For concurrency control in transactions, a dynamic locking mechanism is defined to make sure that the effect of a global transaction executing concurrently with others is the same as if it had executed alone. Deadlock prevention techniques should be implemented to supplement the locking mechanism.

Of the two approaches, the D-DBMS is probably the more appealing to designers who

are provided with transparency regarding heterogeneity and distribution.

A brief description of the "Admiralty Surface Weapons Establishment (ASWE) Distributed Data Base Management System" was given by S.L. Citroen (ASWE, UK). Data management in a distributed command and control system presents more software problems then the centralized approach. Investigation of the problems has resulted in the development at Portsmouth of a system called ADDAM. The system relies on the facilities provided by the ASWE Serial Highway Communication System. ADDAM provides control of the location of the data, maintains consistency and synchronization, and provides an interface to the applications software independent of data location. To achieve this, ADDAM features a combination of partitioning and replication of data. A capability for dynamic reconfiguration gives high system reliability.

Methods and Tools for the Design of Distributed Systems

An overview of the topic was given by R. Lauber, Germany. He began by constructing a model of the development process. One starts with a definition of goals and an analysis and specification of system requirements. The process can then be broken down into three components: conceptual development, which will include design of a solution strategy and algorithms based on the process model; operational development, covering design of the hardware and software system; and auxiliary development, a design of tests and simulation as required.

In the conceptual development it is necessary to consider solution-independent and solution-dependent requirements. These will lead to operational development incorporating the functional design that may be viewed as the design of the man-machine interaction, and software and hardware systems. A breakdown of the development might be whole system, subsystems, functional system, program system, and hardware system.

Lauber gave the following explanation of terms: (1) Development, an engineering activity to bring a technical system into existence, (2) Specification, a description of an object stating its properties of interest, (3) Requirements, a property, whether measurable or not, of a product regarded as necessary, and (4) Specification language, a notational tool to describe the specifications on the different levels for storage in the data base.

A development support system consists of tools and requires a philosophy that will result in a theoretical model of the development process. Development tools can be classed as computative if they provide problem solving techniques, augmentative if they provide aids for slave activities to augment the power of the system, and notational if they consist of language to express information that evolves during development.

Most development support systems today are concerned with software. Aids are needed to support microcomputers and other hardware development. People who are not computer experts need certain tools, including guidelines for the inexperienced user of the system.

Constraints in the Design of Distributed Systems

Prof. B. Randell (Univ. of Newcastle) presented an overview of the constraints in designing distributed systems. He defined a distributed system as an inter-linked set of component computers that can be used together on a task. Various levels of component computers are included as possibilities: a computer and an operating system kernel, a computer and an operating system, or a computer with an operating system and application programs. The interlinking can be some particular type of local area network, a wide area network, or several local and wide area networks.

Systems may be homogeneous or heterogeneous; that is, the elements of the system may be identical, or there may be differences, including controlled or general heterogeneity. The system may be restricted to a fixed configuration, limited to use as a single local area network, or potentially unlimited. The generality of services may be quite varied--the system may provide general computer facilities, specific high level languages, or data-base management. The fault tolerance of the system may depend on the severity of the fault, which may be a computer-link failure, an enumerated hardware fault, validated (erroneous) data, or a residual design fault. The tolerance level of the environment relates to reliability, availability, and acceptability of fall-back. The required security level will depend on whether the system is for commercial or military use: In the latter case, a capability for multilevel security may be required.

A design structuring principle can be to allow a "computing component" to be recursive in order to make the system functionally indistinguishable from its components. The consequences of the principle include support of parallelism and contextual addressing in which all objects in the system must be addressed contextually. The principle makes it much easier to design distributed systems with fault tolerance.

Professor Randell described the work at Newcastle on distributed systems. The system employs the component design principle and the UNIX system, an operating system written at the Bell Laboratories, as a basic component. The latest result is the design and implementation of a subsystem called the Newcastle Connection for uniting multiple UNIX systems. The work is supported by the Science and Engineering Research Council (SERC) and the Royal Signals and Radar Establishment (RSRE). The theme is to reduce system complexity even when fault tolerance is required. Logical concerns are separated.

The system of UNIX components connected by the Newcastle Connection is called UNIX United. It is a distributed system functionally identical to a single UNIX unit. Functions such as file access, device access, and input-output control work across multiple machines. Issues of interprocessor communication and network protocols are hidden from the user. All existing programs using multiple processors can be run in the system. The system removes the need for special protocols for file transfer, virtual terminal remote job entry, and network mail. It subsumes various design system concepts--such as name servers, file servers, and work stations--which are more concerned with heterogeneity than with distributiveness.

A user does not need to know on what machine his program is run. The implementers have decided that the program will be run on the computer in which it is stored. UNIX United allows each constituent UNIX system to have its own set of users, user groups, and user password file as well as its own system administrator. One can unite systems that have already allocated the same use identifier to different individuals.

The Newcastle Connection is installed on top of a UNIX kernel with no changes in the kernel. The connection accepts calls and acts as surrogate for all computers. It is simply a transparent layer of software resting on top of a UNIX kernel. The naming structure of UNIX United represents interrelationships of the component UNIX systems, not their physical interconnections. System administration must agree on the structure, which must not require frequent change. In general, any directory might be a separate UNIX system, even below another system in that hierarchy.

The system is in regular use at Newcastle with five Digital Equipment Corporation PDP-11s connected by a Cambridge ring. An extension of the system, called UNIX United Ltd. (UUL), will provide multilevel security and will use encryption to enforce security barriers and to control permissible reclassification. A prototype has been demonstrated to the UK's Ministry of Defense.

The Newcastle Modular Redundancy uses file and process replication and majority voting to mask hardware faults. The application programs are unchanged through running on several machines with hidden voting. A prototype using three PDP-11s is in operation.

There are no obvious technical problems in using other systems compatible with UNIX in a UNIX United system. This could result in a nationwide UNIX United system.

Software Design for Distributed Systems

An overview of software design for distributed systems was given by G.H. MacEwen, (Andyne Computing Ltd., Ottowa). A distributed system has the following characteristics:

1. An arbitrary number of user and system processes.
2. Modular architecture with a varying number of processing elements.
3. Message passing via a shared communication structure.
4. System-wide control of processing and resource management.
5. Highly variable message delays.

An appropriate system view is that of a virtual network of dynamically extendible processing nodes.

Layers and Interfaces

The notion of a layered structure is probably the dominant principle that has been applied to reduce the complexity of distributed systems. A communications subnetwork processor set of layers consists of hardware components, communication subnetwork services, distributed operating system kernel, distributed operating system services, and user applications programs. In a distributed system problem space there are issues common to all layers: naming, reliability, resources management, abstract objects, protection, measurement, and synchronization and testing. There are also certain global implementation and optimization issues, including state determination, scheduling resources allocation, and measurement and testing.

State determination is an important consideration. At any one time it should be expected that all nodes may not be available, or in a state in which complete up-to-date copies of objects are available. Global state conditions such as deadlock, liveness, and security constraints are often difficult to determine. Maintaining some condition in each node must imply the global condition.

Distributed systems require new semantics to express scheduling constraints on transactions because complete relative timing is difficult to achieve.

The location of resources affects performance in ways that may be evident only to a human analyst. Machine architecture and physical security requirements may make certain nodes more appropriate for certain software. So some combination of direct control and automatic allocation may be necessary.

Measurement and verification is difficult on a global basis and must be an ongoing activity.

Kernel Logic Issues

Three types of primitive objects are defined:

1. The virtual node type that can consist of a single processor with data or an arbitrary number of processors with data.
2. The message type.
3. The virtual node gateway type with operation name, parts, and compound structure.

Synchronization may be any of the following:

1. Buffered no-wait message sending.
2. Unbuffered wait-for-receipt message sending.

3. Remote invocation wait-for-completion open call.

4. Message selection by content, transaction key, or priority number.

5. Time out--with resultant action.

With reliability in communication the issue is to decide between simple, inexpensive primitives that do not mask unreliability versus more complex, expensive types that do. The resource management considerations include: flow control, direct control over mode location, and resource overflow action.

Different virtual nodes in a distributed system may represent the same logical object in different ways. Other nodes in the system should be able to access such objects without regard for their representation or their physical location. The dynamic allocation of abstract objects requires a name creation mechanism. The following specific problems and issues have to be considered: multiple representations, compound objects, object motion, inaccessible objects, object updating, and external representation.

Software Development

The life cycle for software can be divided into informal requirement analysis, requirement specification, design specification, implementation specification, configuration specification, and basic machine code specification.

The requirements need to describe the function, performance, and reliability, and should not take into account available resources. Specifications for designing components of distributive systems include sequential and parallel programs as well as abstract data types. Among the criteria for software development are trustworthiness, safety, and openness.

Certain functions and properties are of special importance to distributed systems: (1) error recovery fault tolerance capability, (2) network structures and protocols, (3) node hardware (heterogeneous or not), and (4) distributed synchronization.

Some important questions are: Should the ADA language be generally adopted? Will extensions be needed? Will different kinds of systems need different language elements, and how much function should be put into the language?

Conclusions

Perhaps the most important development at the workshop was the work at Newcastle described by Randell. UNIX United is a distributed system that is made up of UNIX systems and yet behaves functionally just like a single UNIX system. Furthermore, UNIX-compatible systems can function as nodes in the system in place of UNIX systems. The flexibility in this development greatly simplifies the operation of a distributed system, and the concept should prove useful in the US.

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SYMPOSIUM ON INDUSTRIAL ROBOTS--JAPANESE, EUROPEAN, AND AMERICAN

A 2-day symposium sponsored by Scientific Information Consultants Ltd. and the Technology Transfer Institute on the subject of industrial robots was held on 11 and 12 November 1982 at Melton Mowbray, Leicestershire, UK. The speakers were from the UK, but they discussed robots manufactured in western Europe, Japan, and the US. Most of the talks are summarized below.

Professor W.B. Heginbotham, Production Engineering Research Association (PERA) served as chairman of the first day's session and gave the opening talk on "Proprietary Visual Inspection Systems." He emphasized the need for robots to be adaptable, which in some instances meant contending with disorder. He cited the evolution of the use of lights to control traffic flow as an example of automation. The first traffic lights were monitored by a policeman; later they stood alone but were insensitive to changing conditions, e.g., the build-up of traffic in direction. Traffic lights can now communicate with other traffic lights and can adapt to changes in traffic flow, according to Heginbotham.

Heginbotham discussed cameras used in robot vision systems--thermionic tube cameras and solid state cameras of the line-scan type and the two-dimensional array type. Mention was made of lighting varieties, image enhancement techniques, placement of a camera in the robot gripper, and the vision system in the PUMA, a robot made by Unimation. He then turned to the question of appraisal of the input from the camera. When an image is projected on a grid, various factors aid in its identification. Its area and perimeter, for example, can be computed and compared with the values for objects whose descriptive measurements are available in the microprocessor of the robot system. The object's location and orientation can be determined relative to the grid. According to Heginbotham, the development and use of vision systems are moving more toward inspection rather than control.

A presentation on Pendar Robotics Ltd., was given by Dr. B. Capaldi. He described the Pendar robots as inexpensive, reliable, versatile, and programmable. The Pendar Placemate is a material-handling electropneumatic robot. It uses a closed loop feedback system and a software package to control the pneumatic drives without mechanical stops. The Placemate is a point-to-point machine; the operator programs it with a hand-held keypad, taking the balanced arm through the required work sequence and pressing appropriate learn buttons. The Placemate has three degrees of freedom, which enable the head to be taken to any position within the working envelope of the arm. Placemate robots come in three sizes with 2-, 5-, and 10-kg payload capacities and a range of reach options.

Another Pendar robot, Locoman, will be in production in early 1983. It has the precision needed for assembly work and is still relatively inexpensive. It will have an operational envelope of 500×500×750 mm with a payload of 4 kg at speeds up to 1 m/s. A minimum repeatability of 0.1 mm is maintained at full reach.

Brian D. Sugg, Industrial Robots Division, United Kingdom ASEA Ltd., gave a presentation on his company's robots. He stated that there are 2,000 ASEA robots in use in 30 countries, with 150 in the UK. Payloads cover 6-, 60-, and 90-kg versions in all-electric process robots. The most frequent applications are arc welding, deburring, polishing, gluing, machine tending, and inspecting. ASEA also makes a pneumatically driven modular-construction robot for heavy-duty materials handling with up to 15-kg payloads.

In his talk on "Robots for Assembly" Dr. A.H. Redford, Salford Univ., emphasized the need for improved product design for assembling. He stated that robots can be used effectively and economically for spraying, welding, and bulk handling. However, in assembly it is far more difficult to find applications for robotic devices that are superior to other, more traditional, methods. This is due to increased accuracy required for assembly, the required higher speed of operation, the increased complexity of the tasks involved, and the necessary logic and sensing requirements to perform the tasks.

Assembly robots have an advantage over dedicated assembly work stations. A dedicated system generally is severely restricted in its capability to recover from undesirable situations, but a robot can be programmed to deal competently with many difficulties without needing manual intervention. For their maneuverability, robots depend on a complex computer control system and can respond to sensory information.

Assembly typically accounts for 50% of the total manufacturing work force and 40% of the manufacturing cost. It is therefore reasonable to investigate how the method of assembly can be improved. One should ask whether the product has been designed so that it is easy to assemble. The product designer often gives this much less attention than other factors. The Univ. of Salford and the Univ. of Massachusetts have produced a Handbook of Design for Assembly, which is currently being used by many companies in the US and Europe. Although the handbook deals with manual and automated assembly, much of it also applies to good design for robot assembly.

The designer of a product should examine other products or subassemblies produced by the company to identify those with the same or similar handling or assembly classification numbers. If there are enough identical handling and assembly processes, mechanized or robot assembly equipment probably could be used advantageously. And if similar handling or assembly processes exist, it might be possible to alter the designs so that the processes become identical.

It has been recommended that a coding system for handling parts be developed. This system would be concerned with basic shape, symmetry, and various irregular features. From the code it would be possible to suggest, where feasible, an orienting system suitable for the part, predict the efficiency of the orienting system, and give a reasonable estimate of the cost of the feeding and orienting system. The designer also could recognize features of the part that make it difficult to handle and those that should improve its handling properties. He also may be able to decide what improvements can be made.

The requirements considered necessary for more efficient robotic assembly were given: faster robots; limited capability, cheap robots; versatile, inexpensive grippers; identification of assembly families; improved assembly efficiency; and low cost feeders.

Redford's study was based on six models of various assembly processes, considering production rate, market life, number loading is more expensive than using the feeding system directly.

"Robots and Flexible Manufacturing System as Applied in Japan" was the subject of the talk given by J.A.G. Knight of Nottingham Univ. He based his remarks on a recent visit to Japan. According to Knight, the Japanese are using robots more effectively and more extensively than Europeans and Americans. Because of differences in classification and definition of robots, there are discrepancies in comparing Japanese numbers to those of Western Europe and the United States.

In Japan, more robots are needed in the electrical equipment industry than in the automotive industry. The use of robots for assembly in Japan is expected to increase from 10% of production in 1980 to 20% by 1990. The Japanese share of the US market in robots is now 3% and is expected to increase to 16% by 1985.

Knight quoted some interesting figures about the use of robots by Yamasaki, a machine tool company. The investment in robots was £10 million for hardware and £1.6 million in software. Plant area was reduced from 6500 m^2 to 3000 m^2. Labor requirements were reduced from 218 to 12, a 95% reduction, and the payback time for the system was 2-1/2 years.

Dr. J. Rose, Dainchi-Sykes Robotics Ltd, discussed "Anglo-Japanese Technical Cooperation." Rose said the main business of Dainchi-Sykes was redesign of production lines, chiefly in Germany and France. He made a plea for the UK to accelerate its introduction of robots to increase productivity. To justify research and development, Rose listed qualities sought in robots not now available: rudimentary vision, tactile sensing, computer interpretation of vision and sensing, multiple appendage head to head coordination, computer-directed appendage trajectories, mobility, minimized spatial

intrusion, energy-conserving musculature, general purpose hands, man-robot voice communication, and inherent safety--all at economically justifiable costs.

The last speaker of the first day's session was M.P. Kelly, British Leyland Technology Unit, who discussed management and corporate attitudes toward installation of robots. Such attitudes are influenced by management's commitment to planning and to quality, their concept of the role of computers, their awareness of flexible manufacturing systems, their understanding of competition and of employee attitudes, and their provision of the necessary implementation skills.

Managers need a detailed proposal that will allow them to select the best supplier. In making the choice the whole system, including software support, must be considered. Installing a turnkey system has many advantages and should be considered seriously.

The question of financing a robot installation presents a number of difficulties. Generally management wants a 2-year payback, which is not always feasible. Since the life of a robot may be quite long, the machine should be depreciated over a fairly long period. The advantages of space and materials savings, and quality improvement also should be considered. Finally the price of robots needs to be reduced.

Kelly recommended that all parties concerned with the installation of a robotic system should be brought into the planning from the beginning. Suitable training must be provided, and some development people should be moved into production.

Professor M. Seaman, Seaman Associates Ltd., served as chairman for the second day's session. The first speaker, R. Tilsley of Pera Research and Development, gave a presentation on "The Role of Pera in the Application of Robots in British Industry." He stated that Pera is an independent and objective institution whose role is to respond to customer demand. Pera works on specific problems but usually starts with educational or awareness activity. The work is mainly engineering. Pera provides a robot advisory service for some 700 delegates from industry. The service provides guidelines to industry on the use of robots. For example, the installation cost of a robot is about twice the actual cost of the robot; normally it is not economical to buy a robot to replace one worker, and it is seldom economical to install robots for a single shift.

The prospective user of a robotic installation needs to answer basic questions: what will be its use, will the robot be used to reduce operators, what is the expected payback period, and what is the expected return on investment? These are the key management questions. Pera representatives have visited 385 companies: 79 of these were quickly found not suitable for robots. Twenty-six percent of the others have proceeded with robot installations. Sixty percent of those not acquring robots are delaying because of the recession but plan to proceed later.

Clients are advised not to copy present procedures when installing a robotic system. The objective is to reduce labor requirements and increase throughput. Of those proceeding with installation, 50% are in materials handling, 10% in paint spraying, 10% in assembly, and 30% other.

A presentation on "American Robotics Experience" was given by T.C. Pearce, Unimation Ltd. He showed a film called "PUMA, the Leading Edge," which illustrated the flexibility of the robot in a variety of applications, mostly in iron and steel foundry operations. A report supplied by Pearce gave some examples of impressive savings. For instance, at the General Electric Co. television receiver plant in Portsmouth, VA, six 2511B Unimate Industrial Robots have replaced 18 operators who unloaded a variety of plastic television cabinets from large plastic injection molding machines. The annual savings were $70,000.

A PUMA was used to apply a thin decorative line of contrasting color paint around the face of receiver cabinets. The savings over hand labor in 8 months was $80,000.

J. Wallis, UK Department of Industry (DoI), gave a report on help from the department in installing robots. He said DoI was involved in awareness programs, feasibility studies, applications, and manufacturing.

DoI will pay 50% of 15-man-day feasibility studies, up to a maximum of £3,000; will help install robots; and will provide support until the system has operated for several months at 75% utilization. The government will cover one third of the labor costs during the development period and one third of the cost of the robot.

As of 1 November 1982, DoI received 203 inquiries, approved 64 proposals, and retained 84 under consideration. Eleven proposals have been rejected or withdrawn. Forty-five consulting studies at a total cost of £166,000 have been undertaken, and £79,000 has been paid by the government. Eighteen manufacturing projects at a total cost of £2,619,000 have been undertaken with a government contribution of £1,000,000. Forty-six applications projects have been carried out at a total cost of £12,385,000 with government contributions of £2,853,000. Ninety-two robots have been installed. Suppliers of the robots were as follows: Unimation (15), Asea (23), all others (54). The applications were in the following areas: machine tools (17), welding (35), materials handling (5), spraying (7), assembly (11), and other (17).

The final speaker, Dr. D.S. Allam of Prutec Ltd., discussed ways of raising money for robot installations. He listed public sources that included:

1. Microelectronics Industry Support Program, which gives to eligible applicants assistance up to 33-1/3% of allowed costs.

2. Microprocessor Application Project, which provides industrial awareness and training, consultancy support, initial feasibility studies, and microprocessor application support.

3. Manufacturing Service, DoI, which offers 15 days of free consultancy and a further 15 days subsidized up to 50%.

4. Assistance for the Development and Manufacture of Robots, an agency which offers feasibility studies, robot application support, and design study to the point of manufacture.

5. Research and Development Requirements Boards.

6. Product and Process Development Scheme.

7. Pre-production orders, whereby DoI will purchase qualifying plant and machinery to be placed on trial by a manufacturer.

8. Information Technology, a service concerned with computer assisted design and manufacture.

Private funding through loans is available from many sources, including the Industrial and Commercial Finance Corporation, Technical Development Capital Ltd., Finance Corporation for Industrial Ltd. and Equity Capital for Industry Ltd., clearing banks, merchant banks, and PRUTEC Ltd.

Although the symposium produced no dramatic new information, it provided a good insight into the present state of robotic use in the UK and some comparison among producers in Japan, the US, and Europe.

J.F. Blackburn

ONR London

ELECTRONICS

UNIV. OF EDINBURGH BRINGS IT ALL TOGETHER

The Univ. of Edinburgh, with three times more laboratory capitalization in microelectronics facilities than any other UK university, can afford to be selective in choosing its electrical engineering (EE) students. Only those with A averages are admitted.

Not only are the admissions criteria high, but the course of study is advanced. Third year undergraduate students are required to program complex logic gate arrays in a course called "Gateway." (See ESN 36-11:297 [1982] for the current European industrial emphasis on gate arrays.) Prerequisites for the programming of the gate array are studies in logic design, circuit design, and computer aided design (CAD). Of the 400 students in the EE department, 87 are enrolled in the "Gateway" program at any one time. Thus, to an extent greater than perhaps any other university, EE students at Edinburgh have their appetites whetted for microelectronics.

The EE department recently received the largest award in the history of the UK Science and Engineering Research Council (SERC). With the £2.5 million ($4.125 million) grant, the university will implement a major upgrading of their already notable microelectronics fabrication facility. The upgrading will include installation of an Optometrics direct step on wafer (DSW) 10x projection printer, which (when fitted with a deep ultraviolet [UV] light source) will enable microelectronic circuits to be fabricated featuring submicrometer lithographic resolution. When complete, it will be one of the finest university microelectronics facilities in the world. The first circuits are expected from the facility in time for the celebration of the university's 400th anniversary in the summer of 1983.

Graduate level research in the EE department includes such areas as integrated systems, signal processing, electronic materials and devices, digital systems, machine control, electron microscopy, and microfabrication. In striking contrast to the collage of courses of study offered by some schools, the teamwork, common perspective, and outlook among the various programs of study here are stunning. Not only is the study and development of electronic circuits well integrated, but the school itself appears to be a cohesive organization. The vertical integration from semiconductor materials and electronic devices through logic design, microelectronic fabrication, and even custom very large scale integrated (VLSI) circuit design would be the envy of many reputable semiconductor facilities.

The teamwork is not confined to the EE school; joint pursuits and degrees are entered into with the schools of computer science and artificial intelligence. While others may have been content with having achieved such an integrated and cohesive working organization, the Edinburgh administration founded the independent but adjacent Wolfson Microelectronics Institute, whose purpose is to help industry best to exploit the advances made at the university. Feedback loops among the various groups involved ensure that challenge and competition will continue to stimulate a school that is already superior.

Typical of the research being carried out by the signal processing group is that of a digital adaptive filter using a memory accumulator architecture. Although adaptive techniques using finite impulse response filters are well known, several factors have limited their development. Digital versions have been limited by the complexity of the digital multipliers necessary to achieve large dynamic range (i.e., large digital word size) applications. Analog implementations are generally much simpler and consume less power, but they suffer from limited dynamic range. A new approach taken by the Edinburgh group maintains the large dynamic range capability of

digital technology but avoids the complexity, power dissipation, and cost associated with long-word, high-speed digital multiplication.

Instead, a new algorithm based on distributed arithmetic filter architecture eliminates the multiplier bottleneck. In its place, logic operations are limited to memory access, addition, and scaling by integer powers of 2. The filter uses table look-up to overcome the need for hardware multipliers. The programmability derives from the use of random access memory (RAM) to implement the look-up tables. The technique is ideally suited to adaptive recursive filter implementations. One of the first applications will be that of trunkline telephone data channel equalization. The basic algorithms and architectures used provide for trade-offs between low cost, low power, audio bandwidth applications or video frequency bandwidths with higher associated cost and power consumption.

As lithographic resolution capabilities improve, permitting the width of and spacing between metal conductors on microelectronic circuits to decrease to 1 micrometer and below, "crosstalk" between adjacent conductors becomes a severe problem. Solutions generally involve bringing the conductors closer to an underlying ground plane or resorting to placing ground plane conductors between the signal lines. The problem is particularly severe for 16-bit-wide (or greater) parallel data busses. Researchers at Edinburgh have taken a different approach. They reason that switching speeds of submicrometer transistors will be sufficient to permit bit serial rather than parallel processing on many types of signals. Such an approach eliminates not only the majority of parallel word lines on-chip but also the adverse possibility of cross coupling. Parallel-to-serial and serial-to-parallel converters are used on-chip as input and output buffers, respectively, as required.

Working jointly, the computer science school and the EE school have developed a rather elaborate CAD program directed toward the fast implementation of real-time signal transforms (FIRST). The concept is that of the well-known Mead-Conway approach of "compiling" the complete logic description, mask layout, and processing steps on a computer and forwarding it to a silicon foundry for the fabrication of the VLSI circuit so described. FIRST, however, goes one step beyond the Mead-Conway approach; at numerous points in the development it not only checks for such physical practicalities of fan-in, fan-out, and space limitations, but it also includes built-in fault diagnostics and circuit simulation. The object is to get it right the first time.

The efficacy of FIRST was recently demonstrated. A student having absolutely no microcircuit fabrication experience was given the task of designing custom VLSI circuitry to replace his previously designed signal processing circuit, which used over 120 off-the-shelf transistor-transistor logic (TTL) integrated circuits. He not only was able to design completely and provide the processing lithographic masks for the necessary VLSI circuits, but the school's "silicon foundry" produced the chips so that the entire project was completed and tested within 1 month. The VLSI circuits used the bit serial approach and distributed arithmetic to replace costly digital multipliers in the original TTL design. The final product used but six VLSI circuits--a 20-fold reduction. Without FIRST, such a project would have required at least 24 man-months.

A problem of significant concern in military computers is that of the volatility of the RAM; the entire memory can be lost with even the briefest power outage. Expensive and space-consuming back-up power supplies are now used to prevent memory loss. The electronic materials and devices group has demonstrated a new approach to the development of a nonvolatile memory. The memory cell is not only comparatively fast (e.g., 100 ns to write or erase) but requires only 4 to 8 V and less than a microjoule to switch. The basis of the memory cell is that of a p-n-i amorphous silicon junction set whose HI-LOW resistance ratio exceeds 10^4. Although compatible on-chip decoding circuitry has not yet been developed, the goal is to develop a microprocessor compatible memory array. Initial work was pursued together with the Univ. of Dundee.

M.N. Yoder

ONR London

ELECTRONIC DEVICES TO EXPLOIT LANGMUIR-BLODGETT FILMS?

Fat floats on water. This is common knowledge. It is also well known that fat does not readily mix with water. How can these properties be used to improve the performance of electronic devices?

Molecules which are polar on one end and hydrophobic on the other (e.g., fatty acid) form monomolecular layers on water. Even non-film-forming molecules and molecules whose specific gravity is greater than 1.0 can be made to form monomolecular films on water if they are first mixed with fatty acids. This method was first used 50 years ago to determine the molecular weight of large molecules. Early work with monomolecular films was pioneered by Langmuir and Blodgett. Today these are generally known as Langmuir-Blodgett (LB) films.

Two primary properties of LB films are of interest in the world of electronic devices: the extreme reproducibility and uniformity of their thickness. A typical thickness is 25 Å, although it varies with the type of molecule

used. Multiple layers of the same film or different films can be combined to increase the overall thickness or even to change the electrical properties. LB films are known for their high dielectric strength and excellent insulating properties (e.g., resistivities up to $10^{16}\Omega$-cm). Other important properties for electron device technology include LB films' pinhole-free nature and the near independence of their dielectric constant to frequency changes. Indeed, LB films have been used as model materials for a recently improved technique to measure the dielectric constant.

By changing the molecular structure of the LB films and by intermixing monomolecular layers of differing molecules, virtually any known electrical property can be emulated, and new properties can be synthesized. To be electronically useful, however, the LB films must be transferred from the water surface to a suitable substrate. The general procedure for the transfer is to lift the wholly submerged substrate slowly from the water through the floating monomolecular film at a precisely controlled rate, ensuring adhesion and maintenance of its pinhole-free nature.

This transfer procedure created one of the two biggest problems for LB film technology. Because there was no suitable method to compensate for changes in the area of the floating film as the substrate was being withdrawn, the film tore and pinholes formed. Other problems resulted from vibration, poorly controlled withdrawal speeds, and contamination of the substrate surface by impurities in the water.

Prof. G. Roberts and his staff at the Univ. of Durham have recently developed techniques to overcome such problems. With sensitive microbalance sensors, feedback loops, and microprocessor controllers, a system of moving Teflon belts can dynamically control the molecular float area as the substrate is uniformly and precisely withdrawn through the film without vibration. Contaminant-free quartz water troughs have precision temperature and pH controls and thus provide an ideal environment to float the films. The whole assembly is fitted in a filtered, laminar air-flow cabinet. There are chart recorders for film pressure (as derived from the microbalance), temperature, pH, withdrawal rate, and other parameters of interest. The entire precision apparatus is now commercially available for the first time from Joyce Loebl Ltd., a subsidiary of Vickers. The availability should do much to stimulate LB research.

Many electronic devices are made with LB films: metal-insulator-semiconductor (MIS) diodes, electroluminescent cells, and photovoltaic (solar) cells. The use of LB films in integrated optic devices is particularly interesting because the index of refraction for the waveguiding channels can be synthesized to improve performance. One technique for changing the refractive index is to incorporate metal ions into the molecular structure. Single-mode propagation may require as many as 200 stacked LB layers. Multilayer construction is also used for Esaki structures (modulation doped structures). Certain molecules exhibit a linear variation of dielectric constant with humidity. Films of such materials have been used in hygrometers. Still other interesting electronic phenomena demonstrated by LB films include differential negative resistance (under high electric field and low temperature, e.g., 230°K) and extreme conductivity anisotropy (e.g., 10^8-fold) in anthracene derivative molecules.

The potential of LB electronic applications in two areas is especially significant: the insulating gate field effect transistor (IGFET) and superconductivity.

Several different semiconductor materials have been used in LB IGFET research, including silicon, gallium arsenide (GaAs), indium phosphide (InP), and cadmium teluride (CdTe). Since the control gate insulator is applied at or near room temperature (unlike conventional high temperature approaches), different electrical properties can be encountered. As an example, conventional high temperature approaches generally produce n-channel InP inversion mode IGFETs that are good, but GaAs IGFETs that are extremely poor. The opposite results occur with LB insulating gates. CdTe LB FETs have operated in accumulation, depletion, and weak inversion modes. Critical surface state densities as low as $10^{11}cm^{-2}$ have been recorded on CdTe LB IGFETs.

Interesting types of IGFETs especially amenable to LB technology are the ion-sensitive and gas-sensitive detector devices. The basic mechanism is that of ions adsorbing to the upper LB film surface and influencing the control potential of the FET as a conventional externally applied signal does. Although LB film molecules can be selected or synthesized to favor the adsorption of a given ion or class of ions, other LB molecules are available that are unidirectionally and selectively permeable to specific species of single ions. If such ion-selective molecular layers were applied by more conventional approaches, thicker control insulators would result, causing slower response times and very much longer outgassing times.

Intriguing possibilities are the use of LB FET sensors for monitoring immunological response, enzyme-substrate reactions, and early detection and identification of chemical and biological warfare agents.

If a very thin (e.g., <50 Å) insulating layer is placed between a metal contact and a semiconductor and configured to drop a voltage across the layer, charge carriers can be made to tunnel across the layer so that hot (i.e., at near-saturated velocity) minority carriers can be injected into the semiconductor. The layer properties can be chosen to control the electron-hole injection ratio and thus the effective

gain in a bipolar transistor. In this way, LB films conceivably could lead to significant increases in transistor performance. When the previously mentioned 10^8-fold conductivity anisotropy effects are considered, it is particularly intriguing to consider active LB layers in a transistor acting as their own charge-carrier-confining insulators!

Superconductivity is the second class of electronic application with significant potential. One application is obvious: the tunneling insulator for Josephson junction devices. The reproducibility and uniformity of thickness of LB films not only may lead to stabilizing and better reproduction of critical currents on such devices, but also may provide insulators for the more refractory superconductors not readily obtained by conventional approaches. Another point is that many LB films have been repeatedly temperature cycled to 4°K with no changes of property.

Of much greater interest is the use of LB films to build up organized supermolecule functional units that could exhibit high temperature superconductivity. A composite might be made so that a conducting or semiconducting spline layer is placed very near, but insulated from, another molecular layer with a rich excitonic spectrum. With the precision LB fabrication apparatus described above, the controversial exitonic superconductor hypothesis can now be tested.

Unfortunately for LB films, fat is also slippery. While they may have outstanding electrical properties of great potential, LB films are easily rubbed off the substrates to which they have been transferred. In general, their melting points are also too low for typical military requirements.

In any practical application, it is essential that the LB films be extremely tenacious and thermally stable. These properties were successfully achieved recently at the Univ. of Durham. Earlier experience in the field of xerography led Prof. Roberts to recall the extreme tenacity and thermal stability of phthalocyanine (Pc). A major problem had to be overcome; Pc was virtually insoluble in organic solvents. Several approaches were used to overcome the difficulty. One was to use mixtures of stearic acid. In another, dilithium phthalocyanine ($C_{32}H_{16}N_8Li_2$) was extracted from a mixture of lithium alkoxide in a refluxing alcohol by replacing central hydrogen atoms with metal atoms.

The films produced, however, are generally too rigid for transfer and require a solvent of mesitylene and chloroform for the necessary reduction of viscosity and spreading. The mesitylene is thought to inhibit the close contact required to lock the molecules together rigidly. The chloroform aids film spreading and is allowed to evaporate before transfer to the substrate. The resulting films can be easily transferred at dipping "pressures" of 15 to 20 dyne cm^{-1}. Early experiments provided unusual results; double layers of molecules, not monolayers, were formed. More recently, techniques have been developed to achieve monolayer transfer. Experiments to date show that Pc films stick tenaciously to many common substrates. Although Pc bulk resistivity achieved by evaporation is very high, the LB Pc films exhibit 3.9 x $10^8\Omega$-cm resistivity. Further research is expected to improve resistivity. Temperature cycling between 77 and 400°K has demonstrated the the films' stability.

The new class of films formed from phthalocyanine appear to have overcome the last major problem of LB film technology and could lead to much improved semiconductor and superconducting devices. However, another new materials approach, known as atomic layer epitaxy (ALE), will provide major competition (see ESN 36-10:253 [1982]) .

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MATERIAL SCIENCES

LINE XR7 FOR X-RAY TOPOGRAPHY AND INTERFEROMETRY AT THE DARESBURY SYNCHROTRON RADIATION SOURCE

At Daresbury Laboratory, UK, the XR7 line of the Synchrotron Radiation Source (SRS) is set up to give topography or interferometry results covering the physical, engineering, chemical, and solid state physics properties of crystals. The SRS is described by D. Mosher in "Daresbury Revisited" elsewhere in this issue.

The cover photograph of SRS News, 18 (March 1982), shows a Laue transmission photogram of diffraction "spots." Each spot is 0.65 cm in diameter within the area of a complete slice of natural gem-quality beryl ($Be_3Al_2Si_6O_{18}$) crystal about 1.2 cm in diameter. The diffraction spots recorded through the crystal, about 0.02-cm thick, are of such high resolution that each spot constitutes a projected pictorial image, known as an x-ray diffraction topograph, of the internal strain pattern and structural perfection within the total crystal wafer. Local changes in the photographic record of diffracted intensity are resolved over distances as small as 5 microns. The photogram was obtained in a few minutes with the SRS operating at 1.8 GeV and 190 mA. An exposure of 15 hours is required for an equivalent x-ray topograph of a single reflection obtained with a conventional laboratory x-ray generator and suitable camera.

The beryl synchrotron result was obtained at Daresbury by N. Herres and A.R. Lang,

FRS, Univ. of Bristol, and is to be published in the Journal of Applied Crystallography, 16 (February 1983). The white radiation topography camera used to obtain the result is 80 m along line XR7 from the tangent point to the electron storage ring. The line also contains a double crystal camera for x-ray topography and beam conditioning, a video imaging system for real time studies, versatile environmental chambers for in situ studies, and a liquid helium cryostat for deformation and magnetics experiments. The instrumentation is described in "The X-ray Topography Station at Daresbury Laboratory," an article by D.K. Bowen and S.T. Davies, Univ. of Warwick; G.F. Clark, J.R.S. Nicholson, and B.K. Tanner, Univ. of Durham; and K.J. Roberts and J.N. Sherwood, Univ. of Strathclyde (Nuclear Instrumentation and Methods, 195 [1982], pp 277-284). (Nicholson is now at the Admiralty Underwater Weapons Establishment, Weymouth, Dorset.)

Figure 1 shows the schematic layout of the XR7 line, which is positioned just after the VUV6 beam line containing stations for angle-dispersed photoelectron spectroscopy and for extended x-ray absorption fine-structure (EXAFS) spectroscopy of surfaces. The six experimental stations on XR7 are as follows: 7.1, EXAFS; 7.2, protein crystallography; 7.3, fiber diffraction-small angle scattering; 7.4, x-ray interferometry; 7.5, double crystal x-ray topography camera; and 7.6, white radiation topography camera. The latter three stations, shown on the right side of Figure 1 as "XR7 (continued)," are the subject of this article.

The Warwick, Durham, and Strathclyde investigators have completed productive research with the SRS topography line while developing the instrumentation now available for use. Tanner is particularly interested in magnetic properties and obtained synchrotron results as early as 1976 on the 5-GeV electron synchrotron NINA, which was operated at Daresbury before the SRS. With his former student, Clark, now appointed at SRS, and H.T. Savage of the Naval Surface Weapons Center, White Oak, MD, Tanner has published recent results on "Synchrotron X-ray Topography Studies of the Magnetization Process in $Tb_{0.27}Dy_{0.73}Fe_2$," Philosophical Magazine B, 46 (1982), pp 331-343. The article also reported results obtained at the Deutsches Elektronen Synchrotron (DESY) facility at Hamburg. The rare earth-iron Laves phase compounds exhibit giant magnetostrictions of interest for high power ultrasonic transducers. The configuration of magnetic domains in such compounds is observed in x-ray topographs.

With Clark, P.A. Goddard, and R.W. Whatmore of Plessey (Research) Ltd., Tanner has obtained topographic images of travelling Rayleigh waves on surface acoustic wave (SAW) devices. This involved the development of a method of high frequency stroboscopic x-ray topography. Quartz and lithium niobate SAW devices were used for the method, in which the generation of the surface waves is synchronized with x-rays emitted sequentially in single bunches by the orbiting electrons in the storage ring (see "Stroboscopic Synchrotron X-Radiation Topography and Its Application to the Imaging of Travelling Surface Acoustic Waves," Proceedings of the Hamburg Conference on SR Instrumentation, to be published in Nuclear Instrumentation and Methods [1983]). The method provides a way to study factors affecting SAW device operation, including the interaction between Rayleigh waves and microscopic crystalline defects. Piezoelectric SAW devices are used for high frequency signal processing and filtering applications.

The physics-based Durham group was responsible for developing the XR7 video imaging system. A resolution of 15 microns has been achieved with a fluorescent screen. Radiation damage is no problem with the indirect conversion system, whereby the visible light image is subsequently electronically intensified. Davies, Bowen, and Aleshko Ozhevsky of the Moscow Institute of Crystallography have applied computerized image processing to real time observations of electric field effects and phase transformations in deuterated potassium dihydrogen phosphate crystals. Results have been obtained by the Durham group on magnetic domain boundary motion in hematite, and its phase transformations are to be studied.

The engineering-based Warwick group was responsible for developing the computer-controlled white radiation and double crystal cameras. Bowen is appointed half-time at Daresbury and is a member of the Department of Engineering Science at Warwick. He plans to continue studies of the real time deformation of iron-silicon alloy crystals as a function of orientation, silicon content, and temperature. The deformation stage for the experiments is of a type already used by Bowen with J. Miltat at the synchrotron facilities at Orsay, France, and Novosibirsk, USSR. Orientations are changed on the white radiation camera at a rate of 90 degrees per second. The helium cryostat is designed to give an effective range between 4°K and ambient temperature, with hold times of hours. Deformation and fracture have been studied on crystals of refractory metals and alloys with J.C. Bilello, SUNY, Stony Brook, and with S.R. Stock and H.K. Birnbaum, Univ. of Illinois.

The SRS double crystal camera (DCC) was built at Warwick and was based on the laboratory design of M. Hart, FRS, and D.P. Siddons, King's College, London. The main component is a scaled-up version of a precision two-axis goniometer also used for x-ray interferometry. Angular positions are controlled to 0.01 arc seconds. The DCC (Figure 1) is in front of the white topography camera so that it can also be used for monochromatic experiments

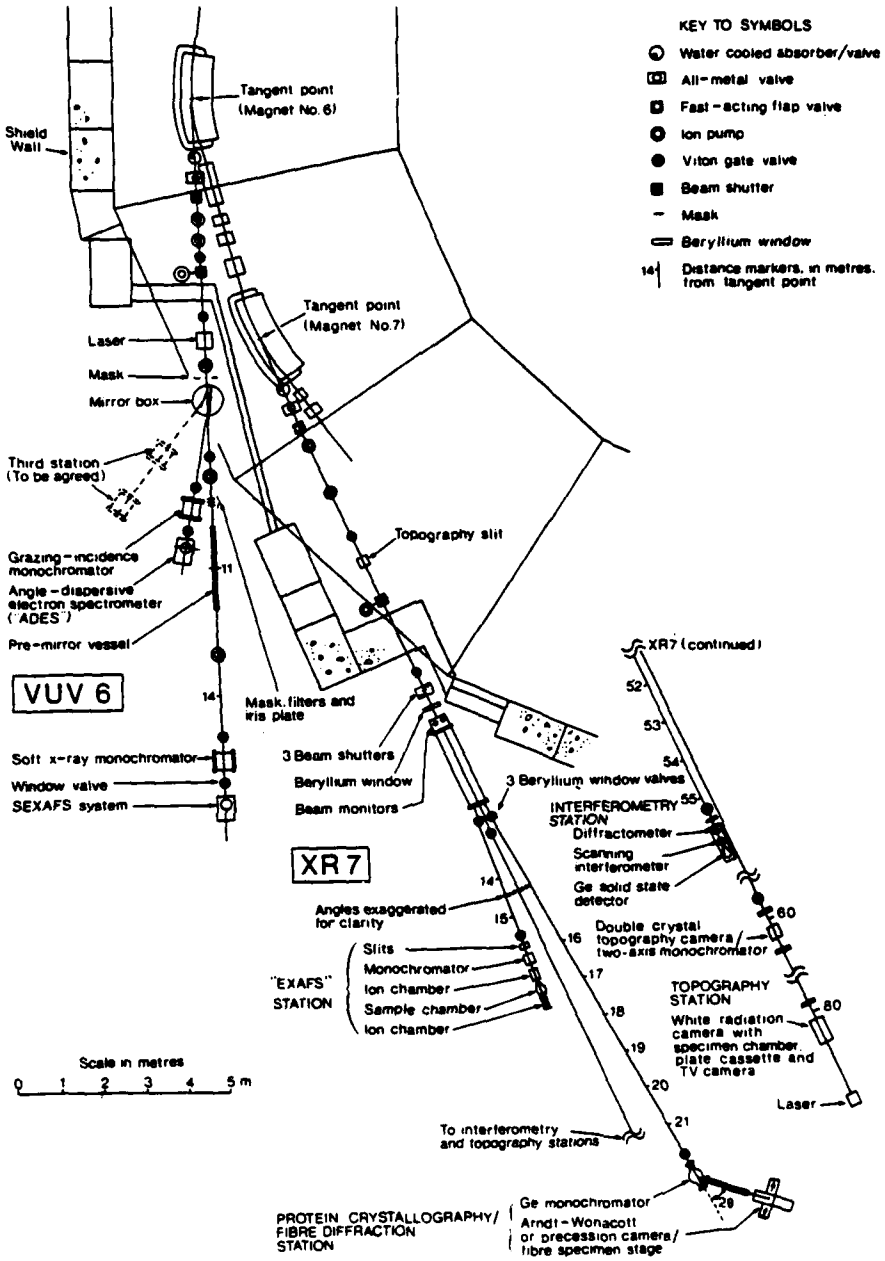

Figure 1. Schematic layout of XR7 line.

such as plane wave topography, differential radiography, and absorption edge experiments to assess variations in states of ionization. The x-ray interferometer allows the complex x-ray forward scattering factors to be determined for elements from measurements of interference fringes.

Siddons and Hart have recently reported measurements for nickel, copper, and selenium (International Conference on EXAFS and Near Edge Structures, Frascati, Italy, September 1982). Previous measurements were made for zirconium, niobium, and molybdenum. Based on application of the laboratory expertise in x-ray optics developed by Hart and colleagues in the Wheatstone Laboratory, King's College, London, such measurements now are proposed to be done routinely using the SRS's high beam intensities and energy resolution in experiments controlled by an interactive microcomputer. Hart recognized early the possible "usefulness

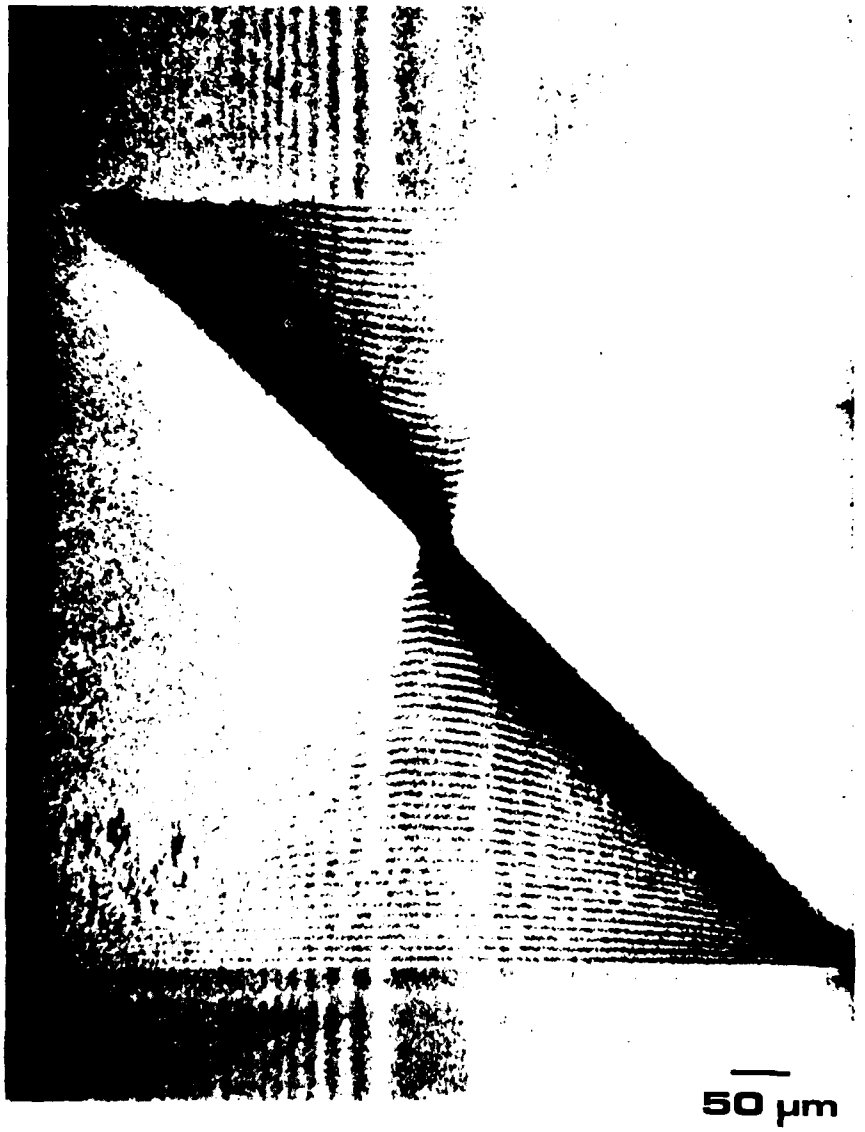

Figure 2. First synchrotron x-ray section topograph of a stacking fault.

of modern synchrotrons for supplying extremely intense, plane wave, polychromatic x-ray beams which can be employed for any number of x-ray experiments to study the structure of solids" (see R.W. Armstrong, ESN 28-10: 384-386 [1974]). But this potential has yet to be realized fully.

The chemistry group at Strathclyde was responsible for the design of environmental chambers for studying the physical and chemical properties of crystal defects. A chamber is available for routine use in the pressure range of 10^{-5} torr to 2 atmospheres and at temperatures up to 1800°K. A clean system that can be baked is available for specialized work. A main interest of the Strathclyde group, however, is in the production of crystals exhibiting either ionic or molecular bonding, including polymer crystals, at or near ambient temperatures. Radiation damage experiments in the synchrotron have been reported for sodium bromate crystals whose thermal or photolytic chemical decomposition is of interest (see K.J. Roberts, J.N. Sherwood, D.K. Bowen, and S.T. Davies, Journal of Materials Science Letters, 1 [1982], pp 300-302). The work was supported by a UK-USSR exchange agreement on synchrotron radiation and has involved A.N. Skrinskii at the USSR Institute for Nuclear Physics, Novosibirsk.

In another UK-USSR exchange, work was reported on the perfection of polybis (p-toluene

sulphonate) diacetylene crystals, after laboratory topography experiments by J.M. Schultz, Univ. of Delaware, on crystals of the same material polymerized in the solid state (see D. Bloor, D.K. Bowen, S.T. Davies, K.J. Roberts, and J.N. Sherwood, Journal of Materials Science Letters, 1 [1982], pp 150-152). Roberts is now with H. Klapper at the Institut für Kristallographie, TH Aachen. Sherwood, in the Department of Pure and Applied Chemistry at the Univ. of Strathclyde, is involved in research on the growth from solution and consequent perfection of energetic (explosive) crystals, such as TNT, PETN, RDX, and HMX crystals. (These crystals relate to topics discussed by R.L. Derr, "Solid Propellants and Explosives," ESN 36-9:199-201 [1982], and V.T. Stannett, "Polymer Research at PERME, Waltham Abbey, Essex, UK," ESN 36-9:206-208 [1982].)

The combined instrumentation now well established on XR7 has attracted new users working on a number of projects. New user groups already having x-ray topography laboratory experience are in an excellent position to achieve worthwhile results immediately. The work on beryl was one example, and Figure 2 shows another. It is the first synchrotron section topograph of stacking fault fringes, observed in this case for a diamond crystal by Lang with A.P.W. Makepeace and Q.L. Zhao, at Bristol, and A.M. Moore and W.G. Machado, at Royal Holloway College, London (see the cover photograph of Physics Bulletin, 33 [December 1982]). It is the first stacking fault fringe pattern recorded with plane polarized radiation.

At the Univ. of Bristol, UK, Lang and S.-S. Jiang (on leave from the Department of Physics, Univ. of Nanjing, People's Republic of China) did an extensive laboratory study of the stacking fault contrast in the crystal as observed with Ag, Cu, and Mo $K\alpha_1$ radiations. The observed fringe patterns are explained by the dynamical theory of x-ray diffraction. The Daresbury (photographic) microdensitometer and computation facilities were used to interpret the laboratory results. The fringe structures were simulated using the computational program of Y. Epelboin (Laboratoire de Minéralogie-Crystallographie, Univ. Paris VI), who is also involved with the Orsay synchrotron facility.

The latest result in Figure 2, which was directly obtained with the white topography camera on XR7, will be shown also on the cover of a forthcoming issue of SRS News. Further information about this result and other SRS news is available from the Editor, P.J. Duke, Science and Engineering Research Council, Daresbury Laboratory, Daresbury, Warrington WA4 4AD, UK.

R.W. Armstrong

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CENTER FOR MATERIALS SCIENCE AND TECHNOLOGY, UNIV. OF DURHAM, UK

The Center for Materials Science and Technology (CMST) has been established as one activity to mark the 150th anniversary of the founding of the Univ. of Durham. The action seems to be a bold initiative during the UK's current financial retrenchment. The establishment of the CMST is a forward-looking, positive step that has been well planned--primarily by Durham faculty members personally involved with different aspects of materials research.

Two leading persons in the CMST activity on the polymer chemistry and structure side are David T. Clark and W.J. Feast in the Chemistry Department. Their research was described as long ago as 1974 by G.R. Husk in ESN 28-11:402, and more recently by W.D. Bascom in ESN 34-3:109 (1980). J. Woods is involved on the applied physics and electronics side; his semiconductor research activities at Durham were reported by R.F. Potter in ESN 29-5:236 (1975). The plan of cooperation these Durham investigators and their colleagues in several departments have produced over the past 3 years has received enthusiastic support from the Vice Chancellor and Warden, F.G.T. Holliday, who has helped muster industrial and government support for the center.

The university points with pride to the external endorsements received for the CMST. For example, F. Hartley, Chairman of the Science and Engineering Research Council (SERC), Engineering Materials Committee, has touted the Durham initiative as one applying the disciplines of physics, chemistry, design, and engineering to a broad range of materials, including metals, polymers, and ceramics. He noted that the CMST brings together people from throughout the university. Furthermore, the participation of the Business School at Durham is an important aspect of the CMST. In this regard, Chemistry and Industry (6 November 1982) quoted D.T. Clark, Chairman of the Chemistry Department at Durham, in describing the CMST as "a materials research center 'custom built for industry.'" The UK Department of Industry (DoI) has provided $1 million for a materials center building, Shell UK has provided $300,000 for a research fellowship, and the Leverhulme Trust has provided $200,000 to cover the salary of the director. A seminar on the CMST was chaired by Vice Chancellor Holliday at the Institute of Directors, Pall Mall, London, on 25 October 1982, at which time support for the endeavor was expressed in turn by W. Waldegrave, Parliamentary Undersecretary of State, Department of Education and Science; K. Durham, Chairman of Unilever PLC; W.F. Madden, Research and Technology Director, ICI Petrochemical and Plastics Division; W.R. Atkinson, DoI North Regional Director; and J. Cunningham, Opposition Front Bench Member of Parliament on Industrial Policy.

One objective proposed for the CMST is to help the economically depressed Northern Region make the transition from its traditional technology, such as ship building, to medium technology, such as polymer processing, and high technology, as exemplified by the semiconductor fabrication industry. Clark and his colleagues in the Chemistry Department are enthusiastic about the plan, which also involves the Departments of Applied Physics and Electronics, Engineering, Geological Sciences, and Physics, and the university's Business School. The research activities in chemistry span the total range in technology; for example, W.J. Feast is involved in self-polishing paints and in the synthesis of advanced polymer structures.

No departmental status or curriculum function is planned for the CMST, and a minimal management staff is proposed. The principal functions of the CMST are to assist in providing a synergistic interdisciplinary focus on university-connected industrial activities, mainly concentrating on research and extra-university education. Short courses, reviews, continuing education, retraining, and secondment programs are to be promoted. Providing facilities to support university-industrial collaborations on research and consultancies is of prime importance. Three representative examples proposed for future productive industries are energy conservation, molecular electronics, and biomaterials--all areas of strong research interest at Durham.

A considerable amount of chemistry-based instrumentation, valued at approximately $2 million, is available within the CMST: extended x-ray absorption fine-structure (EXAFS) spectroscopy; cross polarization magic angle nuclear magnetic resonance (CPMANMR); electron spectroscopy for chemical analysis (ESCA); scanning Auger microprobe (SAM); laser excited mass spectrometry (LEMS); pulsed laser Raman (PLR) spectroscopy; Fourier transform infra-red (FTIR) spectroscopy; scanning electron microscopy (SEM); and analytical scanning electron microprobe (ASEM). The equipment is claimed to provide a unique facility enabling the chemistry group to cover a range of research activities, including surface chemistry, organo-fluoride compounds, organometallics, polymer science, chemisorption, zeolites, and catalysis.

Five members of the 15-member faculty of the Chemistry Department have been specifically identified with the CMST. Besides being head of department, Clark has a wide range of research interests. He is best known for his work with plasma chemistry. Recently he has concentrated on the polymerization of fluorine compounds, such as the fluorobenzenes, for films and for the surface modification of polymers. Novel polymers have been synthesized and their properties investigated. Ring scrambling and other molecular rearrangements in cool plasmas are also under study.

Nitrocellulose chemistry is also a subject of research in Clark's laboratory. He is particularly investigating the difficulties in going beyond a degree of substitution of 2.85. The reasons for the problem are believed to be kinetic in origin. ESCA studies of the surfaces of the original cotton fibers before and during nitration have been made and compared with bulk behavior. The surface aspects of the UV degradation of polymers, including the reasons for the yellowing of polycarbonate films, are also active research topics. The roles of relative humidity and of singlet oxygen are being stressed. The latter is considered unimportant. Clark's group working on theoretical chemistry is concentrating on the structure and binding of reactive intermediates, particularly carbonium ions.

W.J. Feast is mainly interested in polymer chemistry, although he has a strong but minor interest in fluorine chemistry. His interest has led to the synthesis of a whole range of fluorine-containing novel alicyclic, aromatic, and heteroaromatic compounds. Some of the compounds have been used for the synthesis of stereoregular fluoropolymers, normally difficult to prepare. The work has also yielded a novel synthesis of polyacetylene and other "organic metals" as continuous films. A strong research interest is metathesis-ring-opening polymerization, including monomers with aryl, halogen, and heteroatom substituents. A good example is the polymerization of arylpolycyclic olefins such as benzonorbornadiene and related aryl substituted norbornenes. High molecular weights were obtained using, for example, $WCl_6/SnPh_4$ in toluene as the catalyst system.

Step growth photopolymerizations are also being carried out in Feast's laboratory. An example is the photoreductive polymerization of dibenzyl benzenes with m-dibenzoyl benzene. Number average molecular weights of about 3,500 were obtained. More practically oriented studies have focused on various coating applications, including marine antifouling and self polishing paints, ablative coatings, and photo-initiated cationic curing systems.

A.J. Bannister works on sulfur research, especially sulfur-nitrogen (S-N) compounds. He concentrates on the underlying principles of the structure and chemistry of these compounds. In particular he wants to find new and cheaper synthetic routes to $(SN)_x$, a polymer that has remarkable metallic properties and is a superconductor at low temperatures. The usual synthetic route is via S_4N_4, which is explosive. Bannister has developed alternative routes including the use of trithiazyl trichloride, $(NSCl)_3$, and tetrathiazenium chloride, S_4N_3Cl. Some of these have already been described in the open literature (A.J. Bannister and co-workers, Journal of the Chemical Society, Dalton Transactions [1980], pp 731, 937, and [1981], p 2188), and in US Patent 4,268,491 (19 May 1981). Other S-N compounds, including new ring compounds, and heterocyclic synthetic routes are also being investigated.

In addition, Bannister is collaborating with J. Woods in the Applied Physics and Electronics Department to study the electrical properties and uses in semiconductor and other devices for $(SN)_x$ and related polymers.

J. Howard is concerned with various spectroscopic and other techniques for the study of solids, liquids, adsorbed species, zeolite structures, catalysts, and other materials. Among the many techniques used are neutron scattering and diffraction, pulsed picosecond laser Raman, EXAFS, and infrared (IR) and nuclear magnetic resonance (NMR) spectroscopy. Zeolite research includes the changes in structure that occur on heating or adsorption, transition metal exchanged zeolites, ion exchange, its use for hydrogen storage, and other energy-related applications.

J. Yarwood has a major interest in the dynamics and interactions of molecules in liquid and other amorphous phases. Essentially all the modern spectroscopic techniques are, or will be, used together with laser, Raman light scattering, the new pulsed free electron laser (FELIX), quasi-elastic neutron scattering, and the new pulsed infrared source at Daresbury. Topics of current interest are intermolecular torques in liquids, solutions, and liquid crystals, and the molecular behavior of surfactants and model membranes. Fast relaxation processes in amorphous materials and the molecular behavior of lubricants and tractive fluids are also being investigated. Of major importance are the nature and concentration range of micellar aggregation and ultra-cavity trapping by polymers. Studies of iodine-doped polyacetylenes are also in progress.

The other members of the Chemistry Department have a variety of interests, including many aspects of organo-fluorine chemistry, spectroscopy, nucleophilic substitution catalysis, reaction kinetics, and inorganic and cluster chemistry. The total chemistry faculty will also interact strongly with the CMST.

The Department of Applied Physics and Electronics has been involved in research on the fabrication of microelectronic transducers for the chemical industry. The development and application of insulating Langmuir-Blodgett films for controlling charge carrier paths on the nanometer scale is a strong research area at Durham (see M.N. Yoder, "Electronic Devices to Exploit Langmuir-Blodgett Films?" elsewhere in this issue). The films have applications for electronic semiconductor and photovoltaic solar cell devices. G.G. Roberts, head of the department, is mainly involved with this topic. A recent report is "Photovoltaic Properties of Cadmium Telluride/Langmuir Film Solar Cells," G.G. Roberts, M.C. Patty, and I.M. Dharmadesa, Institution of Electrical Engineers, Proceedings, 128 (1980), pp 197-201. Support has been received from SERC, Royal Signal and Radar Establishment (Malvern), ICI Ltd, and Plessey Research (Caswell). An InP/Langmuir film field effect transistor has been produced. Commercially important III-V compounds havebeen studied, and II-VI compounds are being investigated by J. Woods (see "Green Electroluminescence and Photoluminescence in CdS," Physica Status Solidi, A, 70 (1982), pp 325-334. Other departmental interests include silicon device structures; high frequency measurements on oxides, glasses, and semiconductors; and digital electronics involving, for example, fast Fourier transform operations relating to digital signalling and signal processing. A new project undertaken jointly with the Department of Computing is intended to provide an economical high-performance image processing system with large-scale integrated circuits.

Within the Department of Engineering, bioengineering and robotics are two areas of research relating closely to the CMST. Engineering science interests are combined with interests in rheumatology and orthopedic surgery to deal with most aspects of human locomotion, including lubrication of joints, cartilage properties, and prosthetic devices. G.R. Higginson is involved with bioengineering mechanics. Robotics are of interest for flexible manufacturing systems, particularly with regard to designing robots to be produced in the UK. The aim is to produce robots driven with direct-current servo mechanisms having the capability for reaction feedback and at least a limited degree of learning in the programming system. Another departmental interest is machine tool design and operation by P.M. Braiden, who has spent some time in the US with M.C. Shaw.

R. Phillips is a CMST participant in the area of geological sciences. He has traced the origins of ore bodies in the UK and elsewhere. The Department of Geology has complete equipment for mineral analysis connecting nicely with interests in chemistry. An energy conservation topic proposed for the CMST is investigation of the structure and composition of fossil fuels.

B.K. Tanner in the Department of Physics is involved in several research projects connected with the magnetic properties of materials and the use of x-ray diffraction methods to study structure-property relationships. He has designed a number of instruments for measuring either x-ray diffraction or magnetic properties (see D.M. Paige and B.K. Tanner, "A Robust, Inexpensive Torque Magnetometer With On-line Data Analysis," Journal of Physics E: Scientific Instruments, 15 [1982], pp 128-131). He is director of a spin-off company, Bede Scientific Instruments, which manufactures several instruments, including a precision two-axis goniometer with computer controlled electronics. The cost is about $20,000. The CMST hopes to foster accomplishments like Tanner's on a larger scale.

H.C. Baker, Head of the School of Business, and J.H. Bradbury, in Finance, are participants in the CMST. Bradbury prepared the cash flow analysis and has given advice on financial aspects of the center. Other members of the Business School are involved. An area of interest for them is the promotion of finan-

cial support, governmental or otherwise, for starting small businesses. Baker speaks favorably of the US system of promoting the business side of entrepreneurial activities. The development of the center in the context of the total university plan has been the responsibility of J.L.J. Machin, who has been at the Harvard School of Business and a member of the university senate at Durham. He is the 150th Anniversary Appeal Director at the university.

V.T. Stannett
R.W. Armstrong

ONR London

OCEAN SCIENCES

THE CENTENARY CELEBRATION OF FISHERIES RESEARCH IN SCOTLAND

A 2-day symposium on fisheries research, jointly sponsored by the Department of Agriculture and Fisheries for Scotland (DAFS) and the Challenger Society, was held at the department's marine laboratory in Aberdeen on 23 and 24 November 1982. The occasion was the centenary celebration of the creation of the Fishery Board of Scotland "for the improvement of the fisheries," to quote the bill establishing the board.

The first session, largely historical and retrospective, was devoted to papers by two former secretaries of the department, A.J. Aglen and Sir Cyril Lucas, and by the present director of the laboratory, B.B. Parrish.

Since its beginning the Fishery Board (later the Department of Agriculture and Fisheries) has followed a broad definition of fisheries research, and although fishing methods and fisheries management have received due attention, basic subjects have also been emphasized. Early examples include studies of life histories, the environment, fish pathology and parasites, fish taxonomy, hydrography, and plankton studies. Shortly after the turn of the century, the board began to collect statistics on trawl catches on a standard grid, which developed into the International Statistical Grid. The importance of statistics in fishery research was recognized early, and its practical use helped to develop the science of statistics. The scientific flavor of the old Fishery Board is indicated by membership on it of Sir John Murray and of D'Arcy Thompson--among the most eminent scientists of their day.

Although the Fishery Board was concerned almost exclusively with Scottish activities and interests, the international nature of fish and fisheries led to the formation in 1902 of the International Council for the Exploration of the Sea (ICES), which became the repository of information not only on North Sea catch statistics, but also on the physical and chemical environment and closely related information on plankton.

Many of the papers of the symposium were concerned with fishery management by control of fishing practices, such as control of mesh and catch sizes, and even the closure of fisheries of endangered stocks. It had become perfectly clear during the two world wars that man's activities had serious impacts on the stocks, with much larger catches per unit of effort (CPUE) at the ends of the wars than at their beginnings. In efforts to conserve the stocks, the Aberdeen laboratory pioneered in gear studies, especially of trawls and seines. An important part of the studies was on the interaction of the gear and the fish. The research was carried out first by underwater photography with cameras attached to the gear, later by cameras and TV cameras hand held by scuba divers, and most recently by a tethered, unmanned TV camera housing that could be guided from the deck of a ship to various locations relative to the fishing gear.

Between the two world wars there were intensified studies of fish dynamics, and it was demonstrated that the age of fish could be determined from their scales--a fact that made much more significant the statistical study of the fate of young produced during a year (year classes). During the 1920s and 1930s, a coherent theory of fishing was developed, and the changes in CPUEs following the wars could be rationally explained on the basis of the production potential of the stocks.

One of the most basic papers was by Dr. John Steele, formerly of the Aberdeen laboratory, now director of the Woods Hole Oceanographic Institution. He discussed energy flow in marine ecosystems, with models of such flow among the herbivorous zooplankton, invertebrate predators, large and small pelagic fish, and demersal fish species. His theoretical study suggests that there are variable balances between yield and growth that can result in either very high or very low yields. He then presented records of yields of a variety of species; the information suggested that "flips" from high to low productivity actually occur in nature.

In a paper on the "Theoretical Basis of Fish Stock Assessment," R. Jones, DAFS, discussed the effects of exploitation, the "best" level of effort, and the "best" mesh size as factors involved in predicting catches. He pointed out that the maximum sustainable yield depends on factors such as the growth of a stock, recruitment to the stock, and losses to the stock through mortality and catches. Over quite a large range there is little relationship between the stock size and recruitment to the stock, and an optimal harvesting strategy is necessary to ensure the maintenance of adequate stocks.

R.E. Craig, DAFS Aberdeen, discussed acoustical methods of population assessment. He pointed out that for comparable records to be collected, the echo sounders used should be independent of factors such as voltage supply, temperature, and the age of the components. In practice, the transducer is usually mounted about 3 m below the surface. With a vessel travelling about 3 m between transmissions, the typical sample density is about one per second. There is always a "dead" zone close to the sea bed in which fish cannot be detected, and another dead zone close to the transducer.

A major problem in population assessment is converting echo energy to fish density. Three approaches have been used. The first is to catch the target fish, put healthy ones into a cage where they can swim freely, measure echoes from them, and assume that the results apply in the open sea. The second is to anesthetize a fish, tilt it at various angles to evaluate variations in the reflected energy, and then, knowing the tilt angles of natural populations, convert the observed echo energy to population. The third method seems a little more straightforward; in situ measurements of target strength are compared with the population as assessed by trawling. But many uncertainties remain: the fish may react to the presence of the survey ship, and the echo energy depends on many factors--including the species of fish, their depth in the sea, temperature (which modifies activity), and the physiological condition of the target fish. In spite of the many uncertainties, acoustic population assessment has enjoyed some success, as indicated by comparison with catches during survey sampling and the assessment of single shoals of fish.

D.A. MacLennon and P.A.M. Stewart, both of DAFS Aberdeen, discussed fishing gear technology and the development and use of different gears for different target fish. Much of the development has been empirical, but the Aberdeen laboratory has been concerned with fundamental studies of the physics of various gears and components. The commercial gear and methods used in Scotland have been reviewed by E.S. Strange ("An Introduction to Commercial Fishing Gear and Methods Used in Scotland," Scottish Fisheries Information Pamphlet No. 1, 1981).

The hydrodynamics of fishing gear is complicated; for example, the drag forces on a trawl warp are much greater than on a rigid cylinder of the same dimensions, so measurements must be made on full-size gear. Various kinds of otter boards (which keep the mouth of a trawl open during towing) have been developed through the years, largely by trial and error; their lift versus drag as a function of the angle of attack within the ranges of stable towing speeds is under investigation.

The studies are complicated because gear must be developed with a large number of considerations in mind. These include management problems and the effect of the gear on the stocks. Undersize fish and the "by catch" should not be taken. Trawling is energy-intensive and fuel costs are high. In the future, perhaps methods can be devised to get the fish to come to the gear.

R.S.T. Ferro, DAFS, has completed a study on calculating the twine area of a trawl net. The work is important in designing gear compatible with the power of the fishing vessel. Computer programs have been developed at the laboratory to calculate the nominal twine area and to predict the drag of a net over a range of speeds (R.S.T. Ferro, "The Calculation of the Twine Area of a Trawl Net," Scottish Fisheries Information Pamphlet No. 5, 1981).

E.S. Wardle, DAFS Aberdeen, gave an exciting presentation on the behavior of fish during capture. The talk was based on TV observation and simultaneous still photographs, mostly taken from a remotely controlled unmanned vehicle that could be moved with respect to the net.

A.D. McIntyre is the director designate of DAFS Aberdeen. He discussed some of the effects of pollution on fisheries, pointing out that the occasion was not only the centenary of the Fishing Board of Scotland, but also the 10th anniversary of the UN Conference of Human Environment. McIntyre distinguished three scales of consideration: the global situation, regional issues, and local problems.

On the global scale, there are many sources of pollution of the open ocean, the main ones being atmospheric fallout (e.g., DDT and radioactive particles) and offshore shipping. A map of the distribution of oil slicks shows that the slicks are concentrated along the major shipping lanes, as are tar balls. However, the volume and homogeneity of the ocean are such that so far there are no signs of adverse effects of pollution on pelagic fish stocks. Fluctuations caused by natural effects and by fishing pressure have been large enough to mask any effects of pollution. There are open ocean areas where pollutants might become concentrated, such as oceanic fronts and regions of convergence, and the patchiness of various distributions in the ocean is emphasized by oceanographers. But even the obvious localization of oil slicks and tar balls has had no evident adverse effect on fish stocks.

Regional and local areas are a different matter. Enough pollutants may be introduced into major coastal areas to affect significant fishery stocks. The pollutants may not be lethal to the fish but may still produce sublethal and subtle effects on the ecosystem. There is some evidence that trace metals can inhibit photosynthesis (zinc has been shown to do so) or stimulate it. Either effect can cause changes in the community structure and alter the fish stocks. Lethal dinoflagellate blooms occur; they may be within the range of natural and normal variability, or they may result from pollution.

In the Baltic, flounders have been shown to have relatively high concentrations of

polychlorinated biphenyls (PCBs), and eggs and larvae from such fish are less variable than those from controls. The effects of PCBs on the marine mammal population of the Baltic is even worse. Although there is now less hunting of various Baltic seals than in 1900, there has been a steady decline in the populations; PCB in the blubber is correlated with reproductive problems in the seals. Other regional "hot spots" for PCBs are the New York Bight and Puget Sound, where high levels of PCBs have been found in some flat fish.

Local problems tend to be associated with point sources of pollutants, such as outfalls or specific platforms. Such sources may be controled, the effects of pollution may be very local, and they are usually not lethal. McIntyre qualified his conclusion that there is no evidence that pollution poses a threat to pelagic fish stocks, saying that this may be too broad a view and that local fishing operations may be curtailed.

J.H.S. Blaxter of the Scottish Marine Biological Association (SMBA), Oban, summarized a century of experimental research on fish larvae. Although in the early days the species of many fish eggs could not be determined, by 1930 the Dutch had mapped the distribution of plaice eggs in the North Sea. At Millport, the former location of the SMBA laboratory, the diet of fish larvae was studied, and Sir Frederick Russell at Plymouth studied the migration of larvae.

Several attempts have been made to fertilize the ocean by introducing fish eggs and larvae, but none has been very successful. Plaice and cod larvae could be produced in hatcheries quite cheaply, but planting them on the grounds was not particularly effective. Natural variations in the brood strength were so large that they tended to mask the effects of the introductions. There were similar negative results with attempts to transplant cod in Norway and the US. Later attempts with larval plaice grown to a later developmental stage in Loch Ewe were of little benefit to the stocks. Apparently the behavior patterns of the hatchery stock were not like those of the wild fish in matters such as hiding in the sand and avoiding predators.

There have been several attempts to transfer species of fish to new environments, but few have been successful. An early attempt to transfer herring fry from Scotland to New Zealand failed when the stock died in transit. Herring have been transplanted from the Baltic to the Aral Sea; although they survived, they did not thrive. Atlantic salmon transferred to New Zealand failed to establish themselves, but quinnat salmon from the US have become established there.

A.D. Hawkins, DAFS, discussed work on following fish movements using acoustic tags. Juvenile cod enter Scottish lochs in their first summer and are often quite stationary in the habitat. Acoustic transponders are placed in the stomach of the fish, and movements are followed by triangulation of the signals picked up by three hydrophones placed on the bottom and connected to a shore-based computer by cable. Fish have been followed for up to 40 days, and the system can locate them every 1.5 seconds. Within the same species, some fish were found to be active by day, some by night. They appear to have home bases to which they return to rest. The behavior may be an effort to space themselves to exploit the resources with less competition. Another interesting finding was that offshore fish try to swim in straight lines with respect to the water they are in, but tidal movements of the water result in courses that are not straight relative to the bottom.

A.V. Holden of DAFS Pitlochry discussed changes in freshwater quality in Scotland since 1882 and listed some of the "new" pollutants, such as DDT, nitrates from fertilizers, PCBs, and various pesticides. Acid rain is a major problem in Scotland, much of which is granitic; in many forested areas, the pH of steams may drop to dangerously low levels.

There were other talks dealing more strictly with fisheries. A.L.S. Munroe, DAFS Aberdeen; J.E. Thorpe, DAFS Pitlochry; and T.H. Simpson, Aberdeen, discussed, respectively, "The Growth of Fish Farming in Scotland," "Ocean Ranching," and "Farmed Fish: Topics for Research."

In summary, the symposium was primarily a recounting of past and present research in Scotland on all aspects of fisheries, from basic studies of the environment and fish physiology and behavior to modern developments in fish catching, fishery management, aquaculture, and fish farming. Of the 19 papers in the 2 days, 13 were from staff of DAFS Aberdeen, and all the rest were from Scottish investigators, including John Steele (though he is now Director of Woods Hole Oceanographic Institution). The variety and quality of research at the Aberdeen Laboratory is impressive, and it has well earned its good reputation in the world of scientific fisheries.

F.A. Richards

ONR London

OPERATIONS RESEARCH

OPERATIONS RESEARCH APPLICATIONS ON MICROCOMPUTERS

"OR Software for Micro-Computers," a national conference and exhibition sponsored by the Operational Research Society (UK), was held in London on 23 and 24 November 1982. About 120 delegates attended; 15 papers were presented, and software was demonstrated by about a dozen exhibitors. The papers and

exhibitions covered a broad range of applications, from fairly theoretical to very practical, and from general applications ("Robots, CAM and OR") to specific ("Linear Programming Software for Microcomputers").

It is clear that in the UK important advances are being made in the use of microcomputers. There is a high level of interest in developing high quality software for microcomputers, and in making such software commercially available to users around the world. There are also significant efforts in adapting to microcomputers software originally running on minicomputers and mainframes.

Developments in information technology (IT) and their impact on tomorrow's office were described by Martin Cripps (Director of the Wolfson Microprocessor Unit at Imperial College, UK). Cripps briefly reviewed the history of developments in computer hardware and communication techniques; he considers these the two branches of IT. He asserted that with the greater speed, lower power requirement, smaller feature size, and large chip dimensions that are becoming available, we will soon see a hundredfold increase in circuit complexity to 10 million devices per chip.

In addition, new compiler architectures and instruction sets that support better high-level languages will contribute to higher performance, according to Cripps. For IT applications, he pointed out that there is a need for suitable local area networks (LANs) and remote access to large central computers. LANs are still new, and a balance between cost, bandwidth, and siting of the various facilities has not been resolved.

Cripps predicts that before long we will see integrated office work stations with the following features: (1) Computing power--both advanced local processors and access to remote high power machines; (2) Storage--both local and remote data base and electronic filing systems; storage can accept speech, data and facsimile from or for the station; (3) Communications--station linked to others by local and wide area networks capable of transferring speech, data, and facsimile; and (4) Operation--graphics display and voice prompts in a user friendly station designed entirely for use by office personnel.

Lewis Corner (Univ. of Sussex, UK) described two typical applications of microcomputer systems in industrial settings. The first concerned a manufacturer of soundproofing parts for motor vehicles. The firm already had a small microcomputer system for preparing a weekly production process plan. There were about 800 different finished parts, and the company had to take into account customer orders, machine availability, and stocks of raw materials and finished parts. The computer system on hand was inadequate for the job. The problem was partially solved, so production planning that had previously taken at least half a day to complete could be done in less than 30 minutes.

The second application concerned a multinational office equipment service organization. The company wanted to give national service managers information about different service agreements available in several countries for a variety of equipment and utilization factors. A set of programs was developed so that each manager could use menu selection to generate a number of possible outputs, including market summaries, cost and profit data on single types of equipment, product comparisons, break-even output volumes, and optimal models and service contracts for user-specified conditions.

W.B. Dowsland and E. Bischoff (Univ. College of Swansea, UK) presented a paper on "The Computer as an Aid to Physical Distribution Management." The efficient use of transport and warehousing facilities is of concern to many industries. The size and shape of products and the quantities in which they are packed together are often dictated by marketing considerations, with little concern for the impact on distribution and warehousing procedures. The authors described a computer package that gives efficient plans for packaging, transportation, and warehousing of products. The package was originally developed on a mainframe, but it has recently been used on a microcomputer system. One of the problems encountered in the process was the long time required to run the programs, a problem eventually solved by making compromises and improvements in the software's algorithms so that runs could be made on the microcomputer in a few minutes.

In his paper "Decisions, Decisions...," A.J. Williams (PACTEL, London, UK) described several recent developments in decision analysis software. Williams commented that it is more reasonable to judge the quality of a decision making process than the adequacy of any individual decision. He therefore concerned himself with decision processes specifically emphasizing the role of micro-based software in decision support systems. Such systems should help the decision maker to understand better not only what decision should be made in particular circumstances, but also why that decision should be preferred to each specific alternative. The term "decision analysis," often used to describe the assessment process of a decision support system, has a negative connotation to many managers, according to Williams. He prefers the term "risk management," which he says is more suggestive of the positive actions required of managers.

Williams described four software packages related to risk management. Aggregate Utility Comparison (AUC) helps the decision maker choose an option expected to be most useful. AUC's linear model combines utilities for individual attributes. The program is, in effect, an application of the Visicalc spread-sheet package and therefore can be set up and used by anyone having a practical working knowledge of Visicalc.

Multi-User Utility Decomposition (MAUD) is a package developed by Humphreys and Wisudha of the decision analysis unit of the London School of Economics. Like AUC, it can aggregate individual preferences among multi-attributed alternatives. However, MAUD also helps the user to structure and decompose preferences and to decide what are the key attributes to be considered. MAUD is well suited for use by an individual making his own decisions.

ARAMIS is an option-ranking package; it can rank and scale a benchmark set of options, against which any additional number of options can be assessed. To use ARAMIS, a number of judges work separately on the forced pair-comparison of each benchmark option. Then the judges deliberate as a group, scoring each option on a number of characteristics that contribute to the option's degree of "goodness." The package assesses the consistency of paired comparisons among judges and for each individual.

DEXTRA is a decision tree analysis package designed to help compute utilities in complex trees. It can handle trees of up to 180 links, allowing the user to "move" up and down branches, or "hop" from limb to limb to review and modify data attached to each part of the tree. The value held at each node may be a composite of up to four components, weighted to represent utilities of different factors affecting the initial and subsequent decisions. Williams described an interesting pricing policy adopted by PACTEL for DEXTRA: the price of the package to the nth buyer is to be £300 x $n/t^{0.75}$, where t is the total number of buyers of the package before Christmas of 1982. According to Williams, PACTEL will reveal the current value of t at any time for a fee of £10.

Several papers were devoted to financial modeling on a microcomputer. They related to various visual spread sheet approaches, as well as use of "structured" models in which separate files are maintained for the logic, data, and report format specification. There were also papers concerned with graphics (both hardware and software issues), program languages (especially "structured" languages), and simulation packages for microcomputers. The conference also offered demonstrations of various software packages by vendors' representatives. Thus, attendees could interview the representatives, many of whom were the software developers themselves. In many cases, attendees were encouraged to get "hands-on" experience by sitting at the computer keyboards and using the packages themselves.

D.R. Barr

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PHYSICS

DARESBURY REVISITED

The January 1981 issue of ESN contained an article by John Neighbors describing a visit to Daresbury Laboratory, Warrington, UK. He reported on the design and preliminary operation of the Synchrotron Radiation Source (SRS), a 2-GeV accelerator providing radiation in the x-ray regime and dedicated as a source for scientific research.

Since then, operation at design specifications has been obtained, wiggler-magnet and single-bunch systems have been commissioned, and user experiments have begun to yield important results. Dr. Victor Suller, chief accelerator physicist for the SRS, described the advances to the author during a recent visit to Daresbury. This article describes the operational status and configuration of the SRS and outlines the current experimental program. Elsewhere in this issue, R.W. Armstrong describes ongoing materials science experiments using the SRS.

Electromagnetic theory shows that charged particles radiate at a power proportional to the square of their acceleration. For a given accelerator configuration, the lightest particles, electrons, are the strongest radiators. In a high-energy synchrotron, the speed of the electron around the device is almost constant and close to that of light, and the acceleration is centripetal. The synchrotron radiation is emitted over a broad spectral range parameterized by a critical wavelength, λ_c, which divides the spectrum so that half of the total power radiated lies below and half above λ_c. For λ_c in angstroms,

$$\lambda_c \simeq 56RE^{-3}, \quad (1)$$

where the orbital radius of curvature is R(m) and E(GeV) is the electron energy. At highly relativistic energies, radiation is emitted in a narrow cone in the direction of the velocity. The shorter-wavelength portion of the spectrum is more tightly collimated, with the conical divergence angle varying as the cube root of wavelength.

The Daresbury SRS is a 2-GeV storage ring with a 96-m circumference consisting of 16, 1.2-T dipole magnets that bend the stored electron beam into circular orbits; 16 quadrupoles to focus the beam; and a like number of multipole magnets for fine alignment of the beam orbit. A 500-MHz radio frequency (r.f.) system accelerates electrons from the 600-MeV injection energy to 2 GeV and restores the energy lost to synchrotron radiation. At the maximum operating current of 375 mA, the

power loss is 96 kW. A 12-MeV, 3-GHz linear accelerator feeds a 31.8-m circumference, 600-MeV booster synchrotron, which accelerates electrons to the energy required for accumulation in the storage ring. Once the beam is established in the storage ring, a vacuum system pressure below 10^{-9} torr ensures beam lifetimes of 8 to 10 hours. Lifetimes of 25 hours have been achieved at reduced beam current.

During normal operation, the electrons circulate in 160 discrete, 120-ps (3.6-cm-long) bunches separated by 2 ns (the period of the r.f. field). The recently installed single-bunch mode provides a single sub-nanosecond flash each 320-ns orbital period. Stacking a single bunch in the storage ring requires that all but one of the train of 2-ns-spaced pulses produced by the linac be eliminated by two r.f. beam deflectors in the flight path to the booster. The single pulse is then accelerated in the booster and injected into the ring at the precise time required to coalesce with the circulating single bunch.

By the above technique, over 10 mA has been stacked in a single 200-ps-long pulse. For experiments not requiring the full 320-ns orbital period between radiation flashes, further bunches can be stacked at either regular or irregular intervals. The single-bunch mode was envisaged for use in examining the lifetimes of atomic and molecular excited states and for time-resolved spectroscopy. This mode of operation was crucial for recent experiments, which imaged travelling Rayleigh waves on the surface of a piezoelectric crystal by stroboscopic x-ray topography (see the article by R.W. Armstrong; also, R.W. Whatmore et al., Nature, 299 [1982], pp 44-46).

For 2-GeV operation and R = 5.6 m within the 1.2-T dipole magnets, λ_c is 3.9 Å, significant radiation is emitted down to about 1 Å, and the angular full width at half maximum is about 0.4 mrad. The recently commissioned 5-T, superconducting wiggler magnet creates a localized (1-m long), high magnetic-field region which, by virtue of the smaller electron-orbit radius of curvature, produces a spectrum with λ_c = 0.93 Å and significant radiation down to about 0.2 Å. The synchrotron radiation spectra emitted within the dipole and wiggler magnets are compared in Figure 1.

After installation, the wiggler was cooled and its effects on the circulating beam were determined. In addition to enhanced emission of radiation (requiring the refresher r.f. power to be increased), enhanced vertical beam focusing was expected and confirmed. After the 2-GeV beam is stored, the wiggler field must be ramped slowly from zero to maximum. Ramp speeds up to 1 T/min can be used without serious beam disruption. Temporary beryllium windows were fitted at the wiggler port so that radiation could be observed on a fluorescent screen. The use of copper absorbers

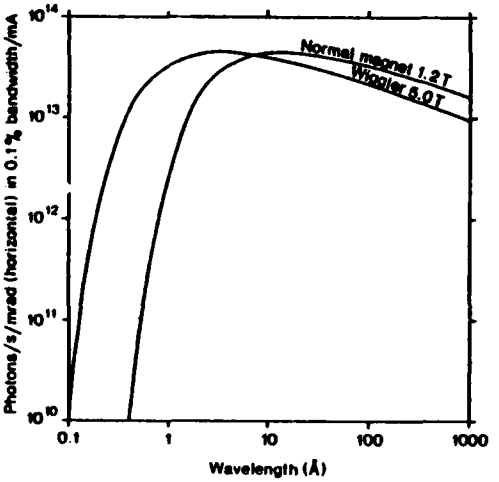

Figure 1. Comparison of spectra emitted within dipole and wiggler magnets.

intercepting the emitted radiation confirmed the presence of photons down to about 0.1 Å.

Synchrotron radiation has a number of unique properties that make it desirable for scientific research. It is intense, orders of magnitude brighter than conventional sources in a number of spectral ranges. The radiation is highly polarized (100% polarization in the plane of the storage ring). It is well collimated, with divergence angles smaller than most laser beams. The radiation has a smooth, continuous spectrum from infrared to x-ray energies. Finally, it has a precise timing structure that can be controlled by r.f. acceleration processes. These advantages have attracted 57 user groups currently performing or planning experiments in physics, chemistry, and biology on the SRS.

Figure 2 shows an up-to-date layout of the SRS facility with existing and in-construction beam lines and experimental stations. Radiation is beamed ahead of the electron bunches as they circulate through the 16 bending dipoles. The radiation emerges tangent to the beam orbit into evacuated pipes that connect ports on the storage ring to the experimental stations. The radiation beam lines are numbered by reference to the magnet from which they originate. Each beam line includes mirrors or transmission windows used to filter out the unwanted portion of the synchrotron spectrum. Thus, experiments on a given beam line are associated with a particular spectral range. Monochrometers and spectrometers at experimental stations further select the radiated wavelengths of interest.

Beam lines 6, 7, 12, and 13 are currently operational. The wiggler line (number 9), and lines 3 and 8 are in various stages of construction. Line 6 is devoted to radiation spanning the vacuum ultraviolet to soft x-ray regimes. No port transmission window is used because

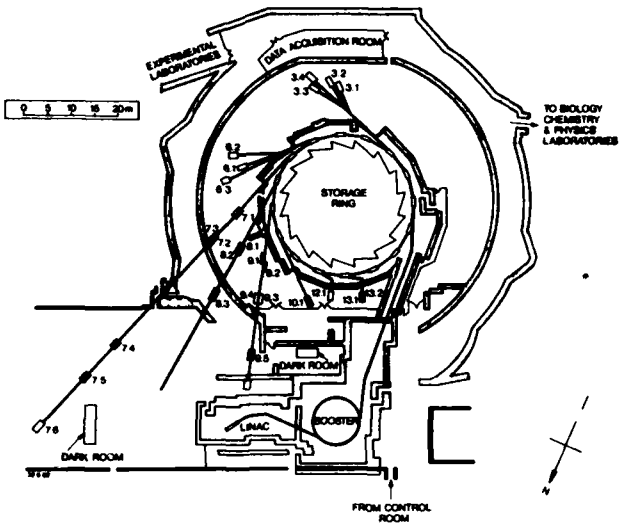

Figure 2. SRS facility layout.

this radiation is strongly absorbed by matter. Stations 6.1 and 6.2 of beam line 6 are devoted to studies of angle-dispersed electron spectroscopy (ADES) employing grazing-incidence monochrometers. Gold-coated quartz reflection optics coupled with a 120- to 1200-Å toroidal grating at station 6.2 provides a flux of about 2×10^{14} photons/s/Å at λ = 200 Å in a 2-mm^2 spot.

The ADES apparatus has been used to test the one-electron potential theory for atomically ordered solids using silver and palladium crystals and photon energies in the 40- to 150-eV range (H.A. Padmore et al., Journal of Physics C, 15, L155 [1982]) on line 6.1. Properties of thin metal layers on metal substrates and the bonding of metallic contacts to semiconductors are also under investigation (R.H. Williams et al., Journal of Vacuum Science and Technology [August 1982]). Photoemission studies of the adsorption of CO on platinum have been carried out, confirming the view that CO bonds molecularly, with the carbon end of the molecule sticking to the platinum surface. A chemisorption study of nitric oxide on platinum is also planned.

At station 6.3, grating and crystal monochrometers covering the 1.5- to 50-Å range and double-focusing, gold-coated quartz mirrors have been installed for surface extended x-ray absorption fine structure (SEXAFS) experiments. The technique has been developed at Stanford during the last 5 years for the precise determination of adsorbate-substrate structural information. Preliminary data with the crystal optics show the L_3 and L_2 edges of iodine adsorbed on a nickel crystal substrate.

Line 7 is devoted to the harder x-ray part of the synchrotron spectrum and employs a beryllium window to filter the softer radiation (see Figure 1). Station 7.1 employs platinum-coated quartz optics and an order-sorting, two-crystal, Si 220 system to generate 2×10^{11} hard photons/s with $\Delta\lambda/\lambda < 3\times10^{-4}$ for extended x-ray absorption fine structure (EXAFS) studies. The harder photons allow for analysis of in-depth structure. Both EXAFS and x-ray absorption near edge structure (XANES) use the fine structure in absorption spectra to determine the local arrangement of atoms surrounding a particular element.

Catalysts, amorphous materials, and biomedical substances are objects of study with the EXAFS technique. One study concerns vanadium oxide catalysts used for the selective oxidation of hydrocarbons. EXAFS studies of metallo-drugs include the chemical action of the anti-arthritic drug Myocrisin during biological reaction. Metallo-enzymes and proteins (C.D. Garner et al., submitted to the Journal of Inorganic Biochemistry) have been analyzed, and calcium EXAFS spectra of bone samples have yielded information about structural changes accompanying the development of bone mineral with age.

XANES measurements on copper and manganese formed the basis for the first publication of scientific research carried out on the SRS (G.N. Greaves et al., Nature, 294 [1981], pp 139-142). Spectra for the two metals were analyzed using a new multiple-scattering formalism. Although the metals have similar close-packed atomic structures, the analysis revealed differences in the detailed local arrangements of atoms.

Stations 7.2 and 7.3 use platinum-coated quartz cylindrical optics and a Ge 111 bent-crystal monochrometer for protein-crystallography, fiber-diffraction, and small-angle-scattering studies. Several projects involve the collection of high-resolution (better than 2 Å) data sets from native and heavy atom derivative crystals. Crystals of the bacterial enzyme that hydrolyzes penicillin have been studied as part of an investigation into resistance to antibiotics. The highly collimated synchrotron-radiation beam is an excellent source for analysis of crystals with long axes, as demonstrated by measurements of hexagonal pepsin crystals with a 300-Å-long axis.

Analysis of biological fibers by small-angle x-ray scattering will begin shortly on line 7.2. Software for operation of the station and digital data processing has been developed for analysis of x-ray diffraction patterns. Stations 7.4 through 7.6, devoted to x-ray interferometry and topography, are described by Armstrong in this issue.

The beam-line optics at ports 12 and 13 reflect the radiation vertically through pipes that pass through the roof of the storage ring tunnel to work areas above the ring. Port 12 uses a LiF or silica window to pass radiation at ultraviolet or longer wavelengths. Aluminum-coated silicon carbide and gold-coated spectrosil optics coupled with a normal-incidence

(>1200 Å) monochrometer will provide 10^6 photons/pulse with 0.1% $\Delta\lambda/\lambda$ in the single-bunch mode for fluorescence lifetime and time-resolved spectroscopy measurements. The station is now being used for beam electron bunch profile measurements using a streak camera, and for some preliminary fluorescence spectroscopy studies of tyrosine and tryptophan.

The infrared (IR) beam port, number 13, was first opened about a year ago, and a Martin-Puplett interferometer in the 2- to 200-cm^{-1} region was used to determine the equivalent "black-body" temperature of the SRS (W.D. Duncan and J. Yarwood, Daresbury Tech. Memo. DL/SCI/TM32E, June 1982). The measurements demonstrated the high intensity (about 50 times that of conventional sources) and good noise characteristics of the SRS. It is planned to use the IR radiation for time-resolved studies on semiconductors and biological molecules, for detailed studies of highly adsorbing materials, and as a calibration standard for other far-IR sources.

Beam line 3 will complement the research conducted on line 6 and will have three stations devoted to high-resolution spectroscopy, angle-resolved photoelectron spectroscopy, and photoionization measurements. Beam line 9, the wiggler line, will extend the research conducted on line 7 to shorter wavelengths by providing 10^{11} to 10^{12} photons/s with energies in the 0.3-, 0.8-, and 1.5-Å bands.

At least one additional beam line is planned for the near future. In a ceremony at Daresbury in the beginning of December, representatives of the Science and Engineering Research Council (SERC) and the Netherlands Organization for the Advancement of Pure Science agreed that Dutch scientists will have access to existing facilities in return for providing a new line with two stations for x-ray studies of material structure.

Details about the accelerator and individual user projects can be obtained by writing the Librarian, Daresbury Laboratory, Daresbury, Warrington, WA4 4AD. The "Synchrotron Radiation Appendix" to the Annual Report for 1981/82 compiled by M.W. Poole and K.R. Lea is especially useful. The appendix contains a status report on the SRS and brief progress reports on all user projects.

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A DUTCH DIAGNOSTIC SAMPLER

During a recent tour of several laboratories in the Netherlands engaged in plasma, atomic, and molecular physics research, the author became acquainted with a number of new diagnostic techniques and processes. This article discusses particle-beam production and utilization for the diagnosis and heating of Tokamak plasmas. The research was done at the Institute for Plasma Physics in Nieuwegien and the Institute for Atomic and Molecular Physics in Amsterdam.

An important new method for the detection of trace atmospheric pollutants is also discussed. In addition, a new fabrication technique for ultra-thin plastic foils developed at the Huygens Laboratory in Leiden is described. The reported research and development projects have additional applications ranging from pulsed-power technology to semiconductor fabrication.

Ultra-soft X-ray Windows

Satellite-based observation of celestial objects at wavelengths between the ultraviolet and x-ray bands has led to a new technique for the production of super-thin plastic foils with a variety of research applications. Radiation in the x-ray ultraviolet (XUV) band (10 to 250 Å) is strongly absorbed by matter so that very thin transmission windows of low-atomic-number materials are required. However, foils used as entrance windows for gas-filled, imaging proportional counters must also satisfy a number of competing requirements related to cross-sectional area, thickness uniformity, mechanical strength, and diffusion leak rate. Such requirements have previously limited transmission to wavelengths less than about 100 Å because of available materials and thicknesses.

Researchers at the Huygens Laboratory, Leiden, and Philips Nederland B.V., Eindhoven, have developed a fabrication technique for lexan windows less than 0.3-μm thick, which extend transmission to 200 Å for the Exosat x-ray telescope. The improved performance over previous state-of-the-art polypropylene windows is shown in Figure 1. Such foils have other applications where durable, large-area

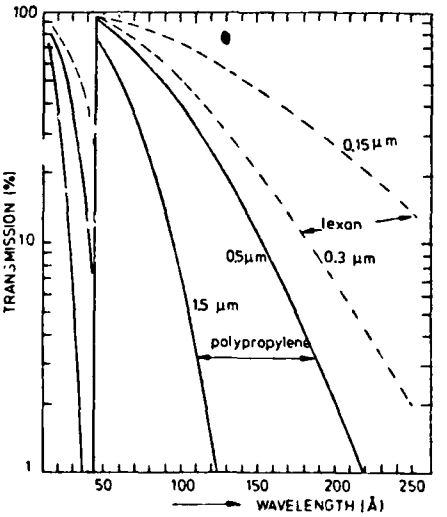

Figure 1. Lexan and polypropylene XUV transmission characteristics.

transmission windows are needed to separate a vacuum from a low pressure gas. For example, a transmission cathode separating an ion diode vacuum from a gas-filled drift space must be as thin as possible to minimize the ion's collisional energy loss. Because the fabrication technique allows precise control of thickness, foils can be made with specific band-pass characteristics for use with a variety of soft x-ray diagnostics to provide spectral resolution in the XUV.

Dr. Dekorta of the Cosmic Ray Working Group at the Huygens Laboratory demonstrated the foil production tool. The device is composed of a water reservoir into which a precisely constructed 12-cm-long by 1-cm-deep trough containing the lexan solution is lowered. As the trough is drawn across the water tank just below the surface, a thin film of the solution rolls off and distributes uniformly on the surface. The plastic film hardens in a few seconds.

The setup must be in a dust-free environment, and the servo motor, which moves the trough at a constant speed, must be mechanically isolated from the tank so that vibration does not disturb the water. Distilled water at about 20°C is frequently renewed and dust filtered. The lexan concentration in solution and the drawing speed determine the film thickness. Because commercially available solutions showed constituent variability and high dust pollution, the Huygens group produced their own lexan solution from dichloromethane with 0.01% dioctylphthalate as a softener and 2% (by weight) lexan 101 powder. The 2% solution and a 1-cm/s drawing speed gave a film thickness of 700 Å uniform to about 10%.

After the film is formed, a stainless steel ring with a 6.5-cm diameter open aperture is lowered at an angle onto the film, dipped into the water, and raised from the tank. The film, which is self-supporting, adheres to the ring and is dried. Water is then flushed through the tank and allowed to come to rest. The process can then be repeated until the desired film thickness is obtained by overlaying on the basic film. To get the desired thickness, lower concentrations can be used to produce thinner films for subsequent layers. By overlaying a number of times, pinholes in individual layers are eliminated from the film.

Films 0.3-μm thick and 7.8 cm in diameter mounted on an electro-etched support mesh can withstand an overpressure of 1 atmosphere and repeated pump down. The films show low permeability diffusion leakage at half-atmosphere pressures when proportional counter gases such as argon plus methane mixtures are used. Low leakage is required because of limited gas-storage facilities on board a satellite. Free-standing films of comparable thickness and 4.5 cm in diameter used as XUV filters can withstand 20-mbar overpressure.

Coatings of aluminum and gold 100-Å thick were applied by vapor-phase deposition at 5×10^{-8} bar. Such thicknesses do not greatly impair XUV transmission but are needed to provide electrical conductivity in proportional counter applications. Thicker metal layers can be deposited to provide light-tightness in filter applications.

Ionization Mass Spectrometry for Analysis of Air Contaminants

Mass spectrometry is a versatile method for analyzing air pollution since it can detect many different species. Unfortunately, the limited dynamic range of conventional instruments makes it difficult to detect concentrations below 1 ppm. For some contaminants, sensitivity several orders of magnitude greater is required. A.J.H. Boerboom of the Biomolecular Physics Group at the Institute for Atomic and Molecular Physics in Amsterdam described a method that alleviates the problem.

While regular air constituents have ionization potentials above 12 eV, almost all contaminants have lower values. If ionizing radiation with energy of 12 eV is passed through the test volume, only the contaminants will be ionized and can then be separated electrically from the bulk of air. A 12-eV electron beam would have a large energy spread and low impact ionization efficiency, whereas a photon beam can be produced with a narrow spectrum and a high photoionization cross-section.

Accordingly, argon-I resonance radiation was chosen with photons at 11.6 and 11.8 eV. A capillary discharge lamp was built to provide 3×10^{12} photons/s in these lines. The region between the discharge and sample gas ionization cell is differentially pumped because any material window would strongly absorb the vacuum ultraviolet radiation. The sample gas is admitted to the test cell at about 10^{-2} Torr, and the ionized components are extracted through a three-electrode lens into a magnetic-quadrupole mass filter with a range of 1 to 100 amu. Ions that pass through the mass filter are deflected by 90 degrees before being counted by a channeltron electron multiplier so that scattered photons are not registered. With the technique, the detection limit for alkanes (methane to hexane) is about 10 ppb. A nitrogen peak at 28 amu is recorded because of a small fraction of above-12 eV photons from higher lying Ar-I and Ar-II lines.

Selective photoionization mass spectroscopy not only improves sensitivity by a factor of 100, but also simplifies the analysis of complex gas mixtures. Figure 2 shows the variety of molecules existing at a given mass and ionization potential. Different molecules with the same mass can often be identified by the mass spectrum of fragments produced by the ionizing radiation. The low energy of argon photoionization in comparison with conventional 70-eV, electron-impact ionization produces a greatly simplified fragment spectrum. (Although easier to analyze, the photoionization fragment spectra of contaminants are not yet so well known as those produced by electron impact because

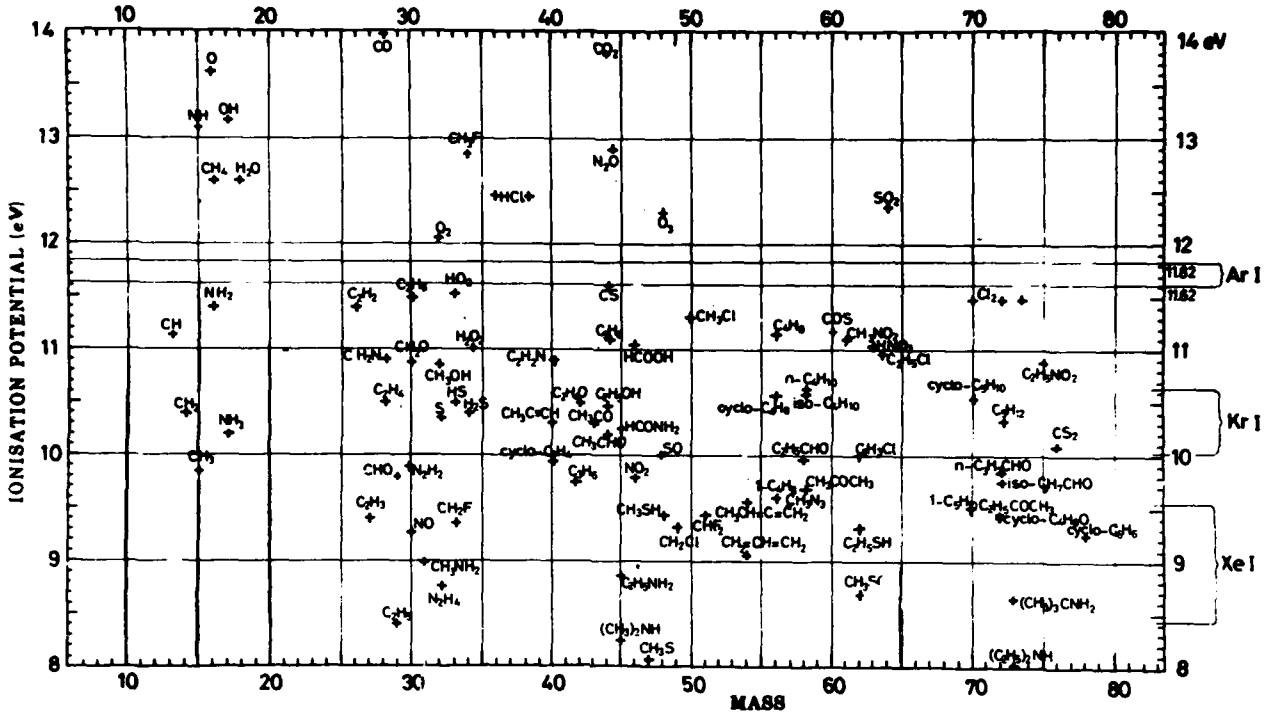

Figure 2. Ionization potentials for molecules at various masses.

research with the new source has just begun.) Further discrimination of molecules with the *same mass can be achieved* by using ionization sources with lower photon energies. As shown in Figure 2, Kr-I and Xe-I resonance lines can selectively ionize subgroups of the full range of contaminants.

Neutral Beam Diagnosis of Plasmas

Much of the plasma physics research carried out in western Europe is associated with the Joint European Torus (JET) experiment at Culham Laboratory near Oxford. JET is administered by the European Atomic Energy Agency (EURATOM). Several similar but smaller tokamak devices in France, Italy, West Germany, and the Netherlands are used for research on plasma heating, magnetic confinement, and stability. The devices serve as test beds for research on various aspects of JET and the proposed, next generation INTOR program. Recently, neutral beam diagnostic components for plasma ion temperature measurements on JET have been evaluated with the small, high-β, TORTUR II Tokamak at the Institute for Plasma Physics at Rijnhuizen in Nieuwegein.

Dr. H.J.B.M. Brocken described the research of the Neutral Particle Diagnostics Group. Neutral atoms of the working gas are usually present in laboratory plasmas and are generated by recombination of ions and electrons or by resonant charge exchange of ions with atoms from the chamber walls. Neutral atoms are not confined by the magnetic field and can freely exit the plasma volume. An energy analysis of the exiting equilibrium neutral flux enables one to determine the ion temperature in low-density plasmas.

At the higher densities and plasma volumes encountered in devices such as JET, atoms suffer a number of charge-exchange events before escaping the plasma interior. Information about the interior temperature is therefore lost. For such applications, an active diagnostic based on the scattering of an injected neutral beam has been proposed. The energy of beam neutrals can be high enough to ensure that some scattered atoms traverse the plasma without charge exchange.

The injected neutral beam probes the plasma cross-section in a narrow cone. A neutral velocity analyzer can then accept scattered neutrals along a line of sight that crosses the injected beam at some angle. The intersection of the analyzer acceptance cone with the neutral beam defines the probed plasma volume. One can then deduce the *local* ion temperature from the velocity distribution of the scattered neutrals. For a beam energy $E_b >> T_i$, (the ion plasma temperature) and small scattering angle θ, the half-width of the scattered neutral energy distribution is given by

$$(1) \qquad \Delta E_{\frac{1}{2}} \simeq 4\theta\sqrt{\gamma E_b T_i \ln 2}$$

where γ is the mass ratio of beam to plasma particles. For application to JET operating in the regime 4 to 8×10^{13} cm^{-3}, an 80-keV hydrogen beam of about 3 ampere-equivalent neutral

current with a 10-cm diameter was chosen.

A computer code was developed to calculate count rates in the velocity analyzer based on profiles determined by Fontenay-aux-Roses personnel in the JET Project Design Proposal. Count rates varying from 10^2 s^{-1} at θ = 20 degrees to 10^6 s^{-1} at θ = 5 degrees were determined with spatial resolution in the beam direction varying from about 20 cm to 1 m. (The D-shaped vacuum chamber in JET has dimensions of about 3 m by 5 m.)

Data would be collected in five angular channels simultaneously with each channel containing its own energy analyzer. The five neutral-particle flight tubes are terminated in 100-Å-thick carbon stripping foils which ionize the beam with about 80% efficiency. A 1- to 2-kG magnet then bends the ions through 90 degrees into the energy analyzer and out of the line-of-sight of unwanted plasma particles and radiation. The scattered energy spectrum is determined by a sophisticated time-of-flight detector. Following the 90-degree bend, each ion creates electrons on passing through a second thin foil. The electrons are accelerated into a chevron channel plate that sends a start signal to a timer. The timer is stopped by the same ion impinging on a second channel plate at the end of a 33-cm flight path. Time-to-analog and analog-to-digital converters are used for data handling. Unwanted analog signals can be rejected by pulse-height analysis designed to select a time channel of interest. Discrimination can be improved further by coincidence counting electrons emitted from the front and back of the start foil with two channel plates. Start signals from neutrons and γ-rays are thereby eliminated because only the ions produce isotropic electron emission from the foil. The coincidence detector will be tested on the ASDEX Tokamak at the Max Planck Institute for Plasma Physics in Garching.

The energy spectrum of charge-exchanged neutrals was used to infer the local ion temperature in TORTUR II experiments. A 25-keV, 2-A-equivalent neutral hydrogen beam was obtained by modifying the neutral heating source designed for the TFR Tokamak at Fontenay-aux-Roses. Charge-exchanged neutrals, which exited the plasma transverse to the injected beam, were analyzed with an eight-channel, time-resolved electrostatic analyzer located beyond a gas stripping cell (H.J.B.M. Brocken, Rijnhuizen Report 80-122, Nieuwegein [1980]). The energy distribution up to 3 keV was measured at 30 to 40 points by making four to five adjustments to the energy analyzer. Large errors in the spectrum below 100 eV were associated with a sharp drop of stripping-cell efficiency at low energies.

Strong plasma heating at high β was obtained in TORTUR II by current-driven weak turbulence. The electron temperature determined by Thomson scattering and soft x-ray measurements agreed with the ion temperature. The ion and electron temperatures and the plasma density scaled with the current, reaching 500 eV and 6×10^{13} cm^{-3} at 35 kA with a 3-T toroidal field.

Negative Ion Beam Development

Currently, neutral beams used for heating and diagnosis of Tokamak plasmas are created by extracting positive ions from a plasma, accelerating them to the desired energy, and then neutralizing them by passage through a gas cell. The process is inefficient (20% neutral-equivalent to ion current even at the low energy of TORTUR experiments) and involves complex gas-handling, residual ion-beam, and vacuum-pumping systems. Moreover, the neutralization efficiency drops sharply with the increased particle energy required in future Tokamaks. Neutral beam heating in the 100-MW range and diagnosis of dense, large-diameter plasmas will require particle energies higher than the few hundred keV/nucleon limit of conventional technology.

Researchers at the Institute of Atomic and Molecular Physics are investigating a solution to the above problem based on the creation and acceleration of negative ions. Because of the tenuous attachment of an extra electron to the atom, neutralization of negative ions by electron stripping is a simple matter even in the MeV/nucleon range. The difficult part of the problem is the efficient generation of high negative-ion fluxes.

A technique that promises to achieve this goal was explained by H.J. Hopman, head of the Plasma Physics group. In their experiment, positive hydrogen or deuterium ions were electrostatically accelerated to energies in the 100-eV to 2-keV range and directed in a 1-mm-diameter beam onto the cesiated 110 surface of a cold, single-crystal, tungsten target. The cesium layer lowers the work function of the surface to 1.45 eV. At grazing incidence, the low work function combined with image-charge effects and electron tunneling result in a finite probability for double-electron exchange between the surface and incident ions (B. Rasser et al., Surface Science, 118 [1982], pp 697-710). For grazing collisions, the particles are reflected specularly with small angular spread so that the beam quality is not greatly degraded, and energy losses during the collision are small. Reflected negative-ion currents are measured with a Faraday cup. Figure 3 shows the experimental results for deuterons.

Results are similar for protons when the energies shown are halved. Nearly 40%-efficient conversion to negative ions is obtained with incidence angles of about 80 degrees. The optimum angle depends on incident energy in such a way that the energy of the motion transverse to the surface is always about 5 eV. This condition reflects the optimum interaction time with the surface for double electron capture.

Based on the above technique, Hopman's group is now constructing a high-current-density source called DENISE to serve as a test bed for neutral heating on INTOR. Protons will be extracted in a 10-cm-long by 2-mm-wide

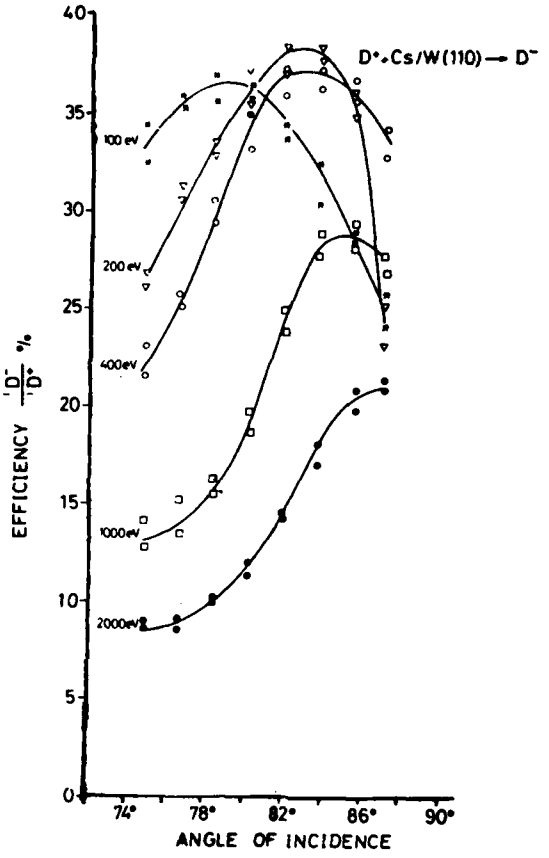

Figure 3. Negative ion production versus incidence angle for deuterons of various energies.

strip from a bucket-type ion source designed for the present JET neutral-injection system. The slit-shaped beam is then accelerated to 2 or 3 keV. Electrostatic lenses will cause the beam to diverge slightly onto 10-cm-long tungsten plates sandwiching the beam. The reflected negative ion beam will then be refocused to 2 mm and accelerated to about 20 keV. Operation at 0.25 A/cm² is expected so that 15 A total negative ion current is anticipated. Once this operating condition has been achieved, two other parallel slits and acceleration-charge conversion systems will be added to demonstrate that the sources can be stacked. Source stacking is required because fusion-plasma heating with hydrogenic neutrals will eventually require negative ion sources with several-hundred ampere capability.

Although neutral-beam heating supplements ohmic heating in JET, it will be of primary importance for the next generation of large fusion experiments such as INTOR. Calculations by L.R. Grisham et al. in a 1980 Princeton Plasma Physics Lab report indicate that the best energy deposition profiles can be achieved with 1 MeV/nucleon particles. Thus, to achieve the 60-MW neutral beams suggested by the present INTOR design, 1 MeV-60 A hydrogen, 6 MeV-10 A lithium, or 16 MeV-4 A oxygen beams will be required.

In addition to plasma heating, such beams might serve the additional important purpose of driving the toroidal current in Tokamaks. Presently, currents are induced with the plasma acting as a transformer secondary. Operation is therefore inherently pulsed. Successful neutral beam generation of currents would allow the steady-state operation of Tokamaks desired for power-producing reactors. High-energy neutral beams would also have advantages for space-based particle beam systems because the beam trajectory would not be deflected from a straight line by magnetic fields.

Dr. E.H.A. Granneman of the Plasma Physics Group described the construction of a compact, radio frequency (r.f.) accelerator designed to accelerate negative-ion beams to the MeV/nucleon range. The acceleration structure is based on the Multiple Electrostatic Quadrupole Array Linear Accelerator (MEQALAC) concept developed by A.W. Maschke of Brookhaven National Laboratory (BNL Report 51209 [1979]). The r.f. accelerating voltage is applied to a large number of gaps separated by strong focusing quadrupoles, which allow for stable transport. The main difference between MEQALAC and conventional linear accelerators is the use of electrostatic rather than magnetic quadrupoles. A second important feature is based on the fact that the maximum space-charge-limited current that can be transported is independent of the diameter of the channel. Thus, in principle, large currents in MEQALAC can be transported in many parallel small channels carrying 1 to 10 mA each, with the minimum diameter determined by the source emittance.

Preliminary experiments will use a 40-MHz, 5-kW r.f. power supply to accelerate four parallel 20-keV, 3-mA, He^+ beams to 100 keV. A 30-mA direct current negative Li source is currently being designed along the same lines as DENISE. It will be used in the second phase of MEQALAC experiments (about 1984) to produce a four-channel, 1-MeV beam. A 25-channel system will be used to create 100-mA, 300-keV, H^- and D^- beams.

Granneman suggests that a 5-mA-equivalent beam of 6-MeV neutral lithium would be a valuable diagnostic for fusion reactions in INTOR. Such atoms have velocities close to those of 3.5-MeV fusion-product alpha particles and can therefore double charge exchange with He^{++} ions moving in the beam direction. By varying the energy of the lithium probe atoms and measuring the neutral helium flux exiting

along the beam direction, the energy distribution of the alpha particles in the plasma can be determined.

MEQALAC accelerator development may have a number of important spin-offs outside fusion research. Since the channel current is independent of diameter, miniaturization leads to an array of small but very bright beams with applications to microscopy or semiconductor etching. Beams on a larger scale might be useful for commercial ion implantation in semiconductors and metals.

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ONR London

THE EIGHTH SYMPOSIUM ON MICRODOSIMETRY

The Commission of European Communities recently held its eighth symposium on dosimetry and interactions of ionizing radiation at a microscopic level. From 27 September through 1 October 1982, about 180 scientists from 20 countries gathered at Kernsforschungsanlage Jülich GmbH, West Germany (FRG) to discuss microdosimetry and its application in biological, chemical, and physical systems.

In 13 oral and four poster sessions, participants reviewed progress on particle track structures, radiation interactions and mechanisms, heavy-ion and soft x-ray effects, cellular and subcellular effects, carcinogenesis, data interpretation, dosimetry methods, and dosimetry for radiation protection and microelectronics. This year marked the first time that microdosimetry for microelectronics was included as a topic. Of the 100 or so papers presented, about one half dealt with biological systems. This division of subject matter reflects the interest in biological and medical applications and indicates the complexity of radiation interactions in biological cells.

This is the 50th anniversary of the discovery of the neutron. W.K. Sinclair (NCRP, Bethesda, MD) opened the technical sessions with a talk commemorating the discovery and reviewing the progress made in understanding the behavior and implications of neutrons in microdosimetry, biology, and medicine.

Progress in understanding and simulating particle track structures was evident in a number of papers. H.A. Wright and J.E. Turner (Oak Ridge National Laboratory [ORNL], Oak Ridge, TN), B. Grosswendt (Physikalish-Technische Bundesanstalt, Braunschweig, FRG), and G. Leuthold (GSF, Neuherberg, FRG) presented papers that demonstrated how computer calculations make it easier to interpret track structures. A.M. Kellerer (Univ. of Würzburg, FRG) and H.G. Paretzke (GSF, Neuherberg, FRG) considered concepts and mathematical constructs that can lead to better descriptions of interactions within tracks and within cells.

Cloud chamber photographs and data for x-rays and alpha particles presented by T. Budd (Atomic Energy Research Establishment [AERE], Harwell, UK) provided visualization of track structures in tissue-equivalent gases. Similar track structures for heavy particles observed in nuclear emulsions was described by E. Wittendorp-Rechemann (Univ. Louis Pasteur, Strasbourg, France). The observations of recoil tracks of C, N, and O nuclei stimulated considerable discussion. There is not yet a consensus on the interpretation and significance of such recoil tracks.

Mechanisms for and interactions of ionizing photons with matter received considerable attention. One area that promises to provide new insights on mechanisms of damage in biological cells is work with low energy x-rays. D.T. Goodhead (MRC, Harwell, UK) presented recent work on biological cell damage as a function of x-ray energy. Exposures made with low energy carbon K-line x-rays (280 eV) suggest that single lesions in DNA may cause cell death.

Some models require multiple DNA strand breaks for biological action to occur. K.H. Chadwick (EURATOM-ITAL, Wagenengen, the Netherlands) also compared ultraviolet (UV) with higher energy ionizing radiation. He found that the UV-induced cell killing is proportional to the square of the exposure. From this, he concluded that pairs of dimers form crucial lesions that constitute the critical form of cell damage in the DNA molecule. Study of the nature and effects of damage produced in DNA will continue to be an active area.

Several papers provided new data on the effects of radiation causing damage, misrepair, transformation, carcinogenesis, and cell death in biological systems. For example, B. Fertil (Institut Gustave-Roussy, Villejiuf, France) presented an analysis of dose rate effects on the survival of seven human cell lines irradiated with gamma rays. The results, when analyzed in terms of the linear-quadratic model, showed significant differences between cell lines. In an invited paper, H.H. Rossi (Columbia Univ., NY) reviewed the present understanding of microdosimetry as it applies to carcinogenesis.

One session was devoted to microdosimetric aspects of microelectronics. P.J. McNulty (Clarkson College of Tech., Potsdam, NY) provided a tutorial background and discussed single particle effects in electronics. J.N. Bradford (RADC, Bedford, MA) compared several analogies of microelectronics to radiobiological microdosimetry. R.H. Ritchie (ORNL, Oak Ridge, TN) discussed calculations on particle track structures in insulators. C.M. Dozier (Naval Research Laboratory, Washington, DC) presented an application of a microdosimetric model developed for radiation chemistry in Fricke dosimeters to electron-hole recombination in the SiO_2 of MOS microelectronics. The presentations pointed out the

similarities that dosimetry in current microelectronic structures have with radiation effects studies in chemical and biological systems. The similarities suggest significant gains in understanding that may result from the interaction of specialists in the various fields.

Proceedings of the symposium are to be published. Further information on the conference and proceedings can be obtained from Dr. H.G. Ebert, Commission des Communautés Européennes--DG XII, 200, rue de la Loi, 1049 Bruxelles, Belgium.

The interaction of biologists, chemists, and physicists specializing in fields as diverse as medicine, radiation chemistry, and now electronics is a hallmark of the microdosimetry symposia. As a result, this uniquely European conference has become increasingly important to the international scientific community, as evidenced by the large participation of scientists from outside Europe. This year's presentations further enhanced the reputation of these biannual meetings.

C.M. Dozier

Naval Research Laboratory

STATISTICS

STATISTICS RESEARCH AT THE UNIV. OF BIRMINGHAM

The Univ. of Birmingham is a "campus university" with all its academic buildings on a single site about 2.5 mi from the center of England's second largest city. About 7,000 undergraduates and 1,500 graduate students study under the direction of about 1,500 academic staff members. The statistics department is headed by Professor J.B. Copas. Members of the department are very active in research, especially in applications related to problems encountered in other departments of the university. Such applications are being made in hydrology, engineering, medicine, and biology.

For a number of years Professor A.J. Lawrance has been interested in time series models in which the assumptions imposed in conventional models are relaxed. As a result of attempts made several years ago to model hydrological time series data, particularly river-flow rates, Lawrance became interested in models in which the records are asymmetric in the time variable, and in which the normality distribution assumptions often made in time-series models are replaced by more suitable assumptions.

Lawrance says he eventually used a first-order autoregressive model with a "weird error term" to express the river flow process. Since then, Lawrance has collaborated with P.A.W. Lewis, D. Gaver, and P. Jacobs (all of the Naval Postgraduate School, Monterey, CA) in developing autoregressive moving average (ARMA) models with non-normal marginal components. Much of the work has been aimed at simulating stochastic point processes by generating data with such ARMA models. Studies of the models make it easier to "fit" the marginal distributions and autocorrelation structures found in certain time series data.

The simulations are useful in examining the power and robustness of statistical tests commonly used in time series analysis. Such fitted models can also be used to generate long series of pseudo data, which can in turn be analyzed to provide inferences about the original process. For example, recorded flow data for rivers typically cover only a few decades, which is hardly adequate for assessing extreme flow levels that might occur in the next century.

But river-flow series are naturally nonnegative, non-normal, and positively correlated for observations made within short times, so a model with the correct marginals and autocorrelation structure can be developed and used to generate long series of pseudo "flow data." The extended data set is used to assess maximal flows (floods), successions of low flow periods (droughts), and other flow characteristics.

Lawrance described a simple version of the models he has been considering, a "first-order autoregressive" structure. Suppose that $\{X_n\}$ is a sequence of random time intervals between successive events in an interval-stationary point process, and assume

$$(1)\quad X_n = \rho X_{n-1} + \varepsilon_n;\ n = 0, \pm 1, \pm 2, \ldots,$$

where $\{\varepsilon_n\}$ is a sequence of independent and identically distributed random variables, independent of the X_n's, and $0<\rho<1$. A basic problem is to find a distribution of the ε_n values that produces a required marginal distribution for the X_n. Let $\phi_X(t) = E(e^{itX_n})$ and $\phi_\varepsilon(t) = E(e^{it\varepsilon_n})$, where E denotes expected value, be the characteristic functions of the X_n and ε_n, respectively. From equation (1) it follows that

$$(2)\quad \phi_X(t) = \phi_X(\rho t)\phi_\varepsilon(t)$$

so $\phi_\varepsilon(t) = \phi_X(t)/\phi_X(\rho t)$. In general, the ratio does not yield a characteristic function. However, Lewis and Gaver showed that if ε_n is a mixture of a random variable degenerate at zero and an exponential (λ) random variable, then $\{X_n\}$ has exponential (λ) marginals. The X_n's are dependent with an autocorrelation function of the form ρ^r. Lawrance has found other solutions to equation (2) yielding marginal distributions for the X_n are gamma, Laplace,

and mixed exponential. He is investigating other models, including second-order models and mixtures of models similar to those in equation (1), which generate sample paths with various desired characteristics.

Professor J.B. Copas has been investigating the use of "shrinkage" to improve the predictive quality of regression estimators. Most statistical theory assumes that the data to be analyzed are compatible with requirements of a specified model. But in practice, the data usually are obtained first and then an effort is made to select a suitable model. The statistician usually starts by selecting a simple model and then refines it to overcome inadequacies. This process could go on until an exact fit is obtained, but the "principle of parsimony" suggests that some unexplained variation should be accepted in exchange for a simpler model.

Belief in parsimony is generally a matter of intuition; it is often accepted that a relatively simpler model should be more stable and provide better predictions when applied to new data. The retrospective fit is what Copas calls the fit of a model to a set of "original data" (where the model is selected on the basis of the data). The fit of that model to new data is called the validation fit. In the regression context, one wants to find a function of observed predictors x_i that gives a good validation fit to an observable response y. Copas pointed out that statistical methods such as least squares, which optimize retrospective fit, do not necessarily optimize validation fit. Thus, a good regression predictor may be inappropriate for other questions in regression analysis, such as testing hypotheses about regression coefficients.

Since assessment of retrospective fit in effect uses the data twice, it gives an overly optimistic picture of the validation fit likely to be obtained with new data from the same experiment. Copas uses the term "shrinkage" to denote the amount by which a subsequent validation fit falls short of the retrospective fit. He has been interested in anticipating such shrinkage and in developing preshrunk predictors. Such predictors would give uniformly lower prediction mean square errors than those achieved by the usual least squares estimators.

Preshrunk predictors are closely related to Stein estimators. The simplest use of Stein estimators is in estimating a mean vector $\vec{\mu}$ of p>3 components, based on a single observation of the vector $\vec{T} = (T_1, T_2, \ldots, T_p)'$ of independent random variables where $T_i \sim N(\mu_i, \sigma^2)$. James and Stein showed in 1961 that the estimator

$$(3) \qquad \hat{\vec{\mu}} = [1-(p-2)\nu\hat{\sigma}^2/(\nu+2)\vec{T}'\vec{T}]\vec{T},$$

where $\hat{\sigma}^2$ is an estimator for σ^2 based on ν degrees of freedom, gives lower expected value of the quadratic loss $(\vec{\mu} - \hat{\vec{\mu}})'(\vec{\mu}-\hat{\vec{\mu}})$ than does the MLE, $\hat{\vec{\mu}} = \vec{T}$. The multiplicative scalar in equation (3) is a shrinkage factor. Because $E(\vec{T}'\vec{T}) = \vec{\mu}'\vec{\mu}+p\sigma^2$, the maximum likelihood vector $\vec{T}$ is further from the origin, on the average, than is the true mean vector $\vec{\mu}$.

It can thus be seen how shrinking the maximum likelihood vector toward the origin might reduce the average quadratic loss. Whether the Stein estimator is useful in practice has been controversial. It seems unreasonable that an estimate of one parameter (say μ_1) should be influenced by unrelated data $(T_2, T_3, \ldots, T_p)$. The quadratic loss function imposes an artificial link among the components allowing compensation between the different estimation errors. Typically, the Stein estimator does better than maximum likelihood in estimating most components of $\vec{\mu}$, but worse (sometimes much worse) in a few of the components.

The shrinkage phenomenon is observable in regression contexts. Copas described an application in which data on production costs of 31 aircraft types were available to estimate the cost of a proposed new aircraft. For illustration Copas selected a random sample of eight aircraft for "original data," and used the data for the remaining 23 cases for validation. Here, y is log cost per unit weight and the x_i's are characteristics such as speed and wing area measured on logarithmic scales. Using stepwise regression, two x_i's were chosen: weight and speed. A plot of observed y versus the predicted $\hat{y}$ is shown in Figure 1.

The fit of the eight selected cases to the line $y = \hat{y}$ is reasonable (as expected). But there is clear evidence of a lower slope for the new cases; the six leftmost points are above $y = \hat{y}$ and the rightmost three points are below. The predictions tend to be too extreme; a preshrunk predictor, which yields the dotted line in Figure 1, gives a smaller expected squared prediction error. Suppose $\vec{x}$ is sampled from an $N(\vec{0},V)$ distribution and it is assumed that

$$E(y|\vec{x}) = \alpha+\vec{\beta}'\vec{x}; \quad Var(y|\vec{x}) = \sigma^2.$$

The fact that $E(y|\hat{y}) = \alpha + K_{\beta}^{\vec{x}}\vec{x}$, where $\hat{y}$ is the least squares predictor, suggests that y should be represented by a predictor of the form $\tilde{y} = \hat{\alpha} + \hat{K}_{\beta}^{\vec{x}}\vec{x}$. Copas has derived appropriate shrinkage factors $\hat{K}$ for various situations. He calls $\tilde{y}$ a preshrunk predictor for y.

A form for $\hat{K}$ is suggested by considering the Stein estimation analogy again. Let M be a matrix such $M'M = V$ and $MV^{-1}M' = I$

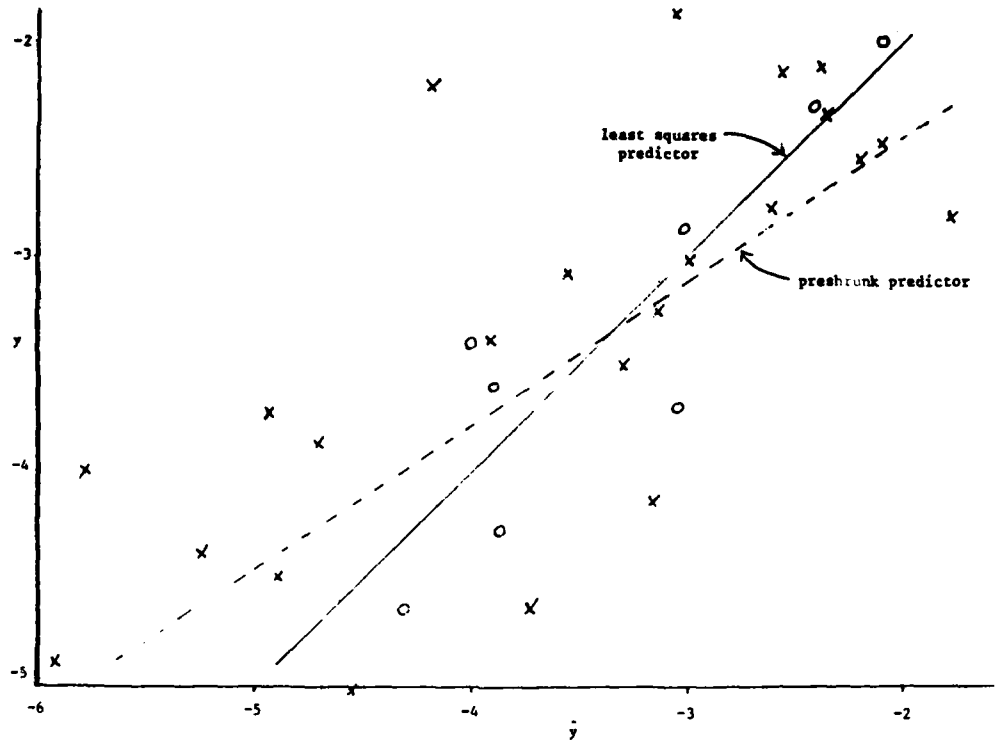


Figure 1. Observed y against predicted $\hat{y}$ in construction sample (0) and in validation sample (x).

[where V = cov($\vec{x}$,$\vec{x}$), as before], and let $\vec{\zeta}^* = M\vec{\beta}^*$. Then $\vec{\zeta}^*$ is $N(M\vec{\beta}, n^{-1}\sigma^2 I)$, so $\vec{\zeta}^*$ has the same distribution as $\vec{T}$ but with $\vec{\zeta} = M\vec{\beta}$ replacing $\vec{\mu}$ and $(n-1)\sigma^2$ replacing σ^2. Applying equation (3) and then transforming back via M^{-1} gives

$$\vec{\beta}^* = [1-(p-2)\nu\hat{\sigma}^2/n(\nu+2)\vec{\zeta}^{*\prime}\vec{\zeta}^*]\vec{\beta}^*$$

$$= \hat{K}\vec{\beta}^*,$$

where $\hat{K}$ is the shrinkage factor obtained by Copas using other methods. The preshrunk predictor of y is then $\tilde{y} = \hat{\alpha} + \vec{\beta}^{*\prime}\vec{x}$.

The quadratic loss function also transforms to

(4) $$(\vec{\beta}^* - \vec{\beta})'V(\vec{\beta}^* - \vec{\beta}).$$

Minimizing this (with respect to $\vec{\beta}^*$) minimizes the prediction mean square error. Copas pointed out that the form of the loss functions used is one reason there have been apparently conflicting results from simulation studies designed to compare Stein and ridge regression estimators with least squares estimators. Some authors have been concerned with comparing estimates using loss functions $(\vec{\beta}^* - \vec{\beta})'(\vec{\beta}^* - \vec{\beta})$. Had their attention been confined to loss functions of the form in equation (4), says Copas, their simulations would have confirmed that y is uniformly better than least squares.

D.R. Barr

ONR London

NEWS & NOTES

THRIVING BRITISH MARKET IN AEROSPACE

British government statistics released in the monthly Overseas Trade Statistics report indicated a healthy aerospace export industry. Total aerospace exports for the first 8 months of 1982 amounted to $3.505 billion, for an increase of about 82% over the same period for 1980.

Although the information is released by the Customs and Excise agency, figures for 1981 are not yet available. The leading British export markets for aircraft parts and engines are the US, West Germany, France, Italy,

Australia, Saudi Arabia, New Zealand, India, and Canada. West Germany is by far the leading market for aircraft parts, the US for engines and parts.

Totals in millions of dollars ($M) for the first 8 months of 1982 are:

Engines & Parts	$M	Aircraft & Parts	$M
US	455.0	W. Germany	409.0
W. Germany	144.7	France	130.0
S. Arabia	67.5	US	125.4
India	54.1	S. Arabia	116.2
All nations	1,373.3	All nations	1,780.5

Sales of new engines ($613.8 million) somewhat exceeded sales of engine parts ($547.3 million). Sales of aircraft parts ($1,280.3 million) more than doubled sales of new and used aircraft ($500.2 million). Other major sales categories are instruments ($160.2 million), guided weapons ($82.7 million), and radio and navigation aids ($27.5 million). Many sales records have been set during 1982.

British Aerospace, long known for its civil aircraft and satellite construction programs, has recently contracted for $680 million to build the cradle for the US satellite communications system known as LEASAT that will be launched by the Space Shuttle. LEASAT includes five satellites to be built by a subsidiary of Hughes Aircraft Company and leased to the Navy. The cradle system will support an 8000-kg satellite in the Shuttle's cargo bay during launch and subsequent ejection into geostationary orbit.

R.L. Carovillano

ONR London

SUPER BUGS AND SUPER SLURRIES

The genetic engineering of microbes to benefit mankind is not new. For example, organisms have been developed to digest petroleum and petroleum products and more recently 2,4,5-T (Agent Orange).

Workers at the Univ. of Liége, Belgium, have recently created a microorganism that can remove 90% of the heavy metals from industrial wastes. And although silver is normally highly lethal to bacteria, it has been found at Univ. College, Cardiff, that a mixed culture of Thiobacillus ferroxidans and Thiobacillus thiooxidans can concentrate silver.

Removing heavy metals from industrial wastes is of obvious environmental importance, but the UK is faced with a more mundane problem that might be solved with biotechnologies. Since the 1960s, the number of dairy units with more than 100 cows each has increased by a factor of eight, there are nearly 12 times as many piggeries with more than 1,000 animals, and the number of poultry farms with over 20,000 chickens has doubled. The slurries and manures from the cattle and pigs are now five times the volume of wastes from industrial and sewage treatment plants in the European Economic Community (EEC), and few operators use the high quality anaerobic digestion equipment manufactured in the UK.

A report prepared for the Scottish Development Agency contains an estimate that sewage, livestock, industrial, and municipal wastes generated in the EEC have an energy value equal to about 33 million tons of oil.

West Germany appears to be pushing ahead faster than the UK in marketing conservation-based technologies, but the Confederation of British Industry has announced a Pollution Abatement Technology Award Scheme to begin later in the year. The scheme is expected to spur development of the British technologies.

If the answer to some of the above problems is a more advanced biotechnology, help may be on its way. On 24 November 1982, the UK Department of Industry (DoI) launched a new 3-year, £16 million program of support for biotechnology. The funds are considered seed money to be used on consultancies, research, and demonstration projects. In addition, £14 million is being spent on commercial projects through the British Technology Group. A program of capital investment will use £2 million to develop pilot plant facilities at the Center for Applied Microbiology Research at Porton Down and to establish a national collection of animal cells and hybridomas. Another project is to develop a process for making microbial plastics from microbes. Leading programs will be in research on biosensors and on elements of process engineering including fermenter design and the large scale growth of mammalian cells.

(From an article by John Elkington, "The Super-Bugs That Thrive on A Toxic Diet," The Guardian, 18 November 1982, and the New Scientist).

F.A. Richards

ONR London

ESTIMATING NUCLEAR EFFECTS

On 11 November 1982, a meeting sponsored by the Social Statistics Committee of the Royal Statistical Society, chaired by Dr. Jeff Evans, was held at the London School of Hygiene and Tropical Medicine. A featured presentation, by Ms. Allison MacFarlane (Oxford Univ.), was entitled "The Nuclear Numbers Game: Estimating Effects of Nuclear War." Although Evans introduced MacFarlane as a leader of the "radical statistics and nuclear disarmament group," the presentation remained generally professional and objective. The talk was interesting and a lengthy discussion followed.

It is difficult for statisticians in the civilian sector to estimate precisely effects such as casualties resulting from nuclear attack on Great Britain. First, data on nuclear effects

are difficult to obtain. (Most of the sources cited by MacFarlane were of US origin--from the US Office of Technology Assessment, for example.) Second, the number of casualties suffered in a nuclear attack appears to depend on factors such as time of the attack, wind direction, amount of advance warning, and the attack scenario (e.g., targets, sizes and numbers of weapons). Third, scientific knowledge about the effects of nuclear explosions on human populations is incomplete. For example, long term effects of the attack on Hiroshima and the Nevada tests are still being determined.

In the unclassified literature, available studies estimating effects of nuclear explosions tend to give results that are in marked disagreement. For example, various groups have estimated that the number of deaths at Hiroshima ranged from 42,000 to 133,000. As another example, estimates of the radiation dosage corresponding to "LD-50" (the dosage which would cause death in half the humans receiving that dose) vary widely in various reports available to the general public.

Two conclusions can be drawn. First, responsible groups in the European civilian sector are trying to learn about various factors relevant to decisions on nuclear policy. Second, it is rather difficult to make sound inferences in this area, in part because much of the world's data is not generally available.

D.R. Barr

ONR London

AIR CRASH PLAYBACK

A Dan-Air BA 748 airplane crashed last year as it was on the mail run from London's Gatwick Airport to Leicester; all three crewmen aboard were killed. For some years it has been conventional practice to follow up such accidents with a detailed analysis of the wreckage, the radio transmissions between the plane and the ground, and the material recovered from flight data recorders (FDRs). The Aircraft Investigation Branch (AIB) at the Royal Aircraft Establishment in Farnborough has introduced some new features into the "playback" of events just preceding the crash.

Flight instrument data, as recovered from the FDR, are converted into a form suitable for dynamic playback on a video screen. In this way the analysts can "re-live" the events the crew experienced just before the crash. One may study the way the instrument panel must have looked, and so forth. In the Leicester crash, the aircraft went into a steep dive as the rear door blew open (the door was hung up on the tail for most of the descent); the pilot frantically tried to regain control, but finally the wings came off. The "porpoising" of the craft during the final moments of flight is most dramatic and most informative.

The AIB researchers are also working on enhancing the quality of cockpit voice recorder data. Often the raw tapes are quite unintelligible; but after suitable processing, the spoken material is more understandable. Another benefit of "enhanced" speech analysis is that it may also improve the intelligibility and separability of engine and control sounds. AIB also is pressing for more parameters to be recorded in FDRs and for more modernization and standardization of such instruments in commercial aircraft. Older FDR boxes record only five or six channels of information, but newer techniques now permit a much more reliable and complete data collection process, with little or no increase in weight.

N.A. Bond, Jr.

ONR London

PROBABILITY TEXT PUBLISHED

Dr. Donald R. Barr of the ONR London Office and his colleague, Dr. Peter W. Zehna of the US Naval Postgraduate School, Monterey, CA, have published the book Probability: Modeling Uncertainty (Addison-Wesley Publishing Co., Inc., Reading, MA 01867, 1983, 480 pp). The book contains examples from operations research, science, and engineering. It could be used as a text in various courses and includes exercises and problems, some of which are computer oriented.

Dr. Barr is on leave from the Operations Research Department of the Naval Postgraduate School.

F.A. Richards

ONR London

AUTOMATIC BREATH-TESTING MACHINE

A Welsh firm is successfully marketing an automatic breath analyzer for suspected drunk drivers. The whole "Intoximeter" system is about the size of a typewriter and uses standard computer chips. It prints out immediately the estimated blood alcohol content of an individual and statistical dispersion values of the estimates.

Recent changes in British law permit the police to use such machines, which are now expected to replace the less convenient tests on blood or urine samples. Many units are being installed in British police stations; the Metropolitan force of London has ordered dozens.

The manufacturer is Lion Laboratories of

Barry, South Wales, UK. At present exchange rates, each unit costs about $4,500, US. If the Intoximeter proves equal to scientific and legal challenges, it could become the European standard for measuring blood alcohol and possibly other causes of intoxication.

N.A. Bond, Jr.

ONR London

HAND ANTHROPOMETRY STANDARDS

The British Army Personnel Research Establishment (APRE) has just published a thorough compendium of data on the human hand. A new measuring system was applied, and 62 measurements were recorded on each hand of 487 people. Summary results are available in statistical tables (means and percentiles) and in scatterplot form.

APRE also maintains a hand data bank which can be queried by professionals. The material--probably the most complete set of hand data in the world--can be requested as APRE Memorandum 82M510, available from APRE, c/o Royal Aircraft Establishment, Farnborough, Hants, UK.

N.A. Bond, Jr.

ONR London

COMPEDA TAKEOVER BY PRIME

In a recent issue of ESN, the rapid growth of the UK company named COMPEDA was described (ESN 36-4:82 [1982]). The latest development regarding COMPEDA was reported in The Sunday Times, London, 12 December 1982.

COMPEDA was founded in 1979 with government backing to provide product development support and worldwide marketing for high-technology software produced by government-sponsored research organizations. Industry, government laboratories, and universities have developed products packaged and marketed by COMPEDA. By 1981, COMPEDA had established overseas offices in the most competitive market areas; the company ended the year with total revenues of £2.8 million, and for the first time no net loss. COMPEDA's main success has been in computer aided design and manufacturing (CAD-CAM), particularly in areas with a heavy engineering emphasis, such as computer design of plants and machinery.

The Times has now reported that COMPEDA is in the process of being purchased for £5 million by the US firm Prime Computer, Inc., Framingham, MA. To protect their national investment and interests, the UK has required as part of the takeover that the British firm Quest be given nonexclusive marketing rights to COMPEDA's latest software products for designing cars and planes.

R.L. Carovillano

ONR London

TIN COMPOUNDS PROVE VERSATILE

The tin woodman in the Wizard of Oz had problems with water--but not because of his tin. What he needed was a little bit of the proper organic moities to go with it.

According to the New Scientist, workers at the Tin Research Institute in Perivale, West London, have come up with a process for waterproofing fabric based on soaking the materials in organo tin compounds; a typical one is butyl tin trichloride. The tin bonds to the fibers, leaving the organic part, which is water repellent, protruding from the fibers. The principle differs from ordinary wax or resin coatings, which stiffen the cloth and cause condensation. The new method results in a cloth that neither makes you sweat nor costs a lot of money.

Other investigations at Perviale suggest that some organo compounds (monoalkyl tin-based salts) may make fabrics less flammable. Similar compounds have been used as additives to make plastics more resistant to heat. It has also been suggested that organic tin compounds may be useful in preventing wood rot and as insecticides.

The combination of possible properties--water repellent, fire resistant, insect proof, and safe from wood rot--is appealing. And the tin woodman might not have needed oil for continued locomotion.

F.A. Richards

ONR London

MARINE RESEARCH INSTITUTE

The library of the Marine Research Institute in Reykjavik, Iceland, publishes a bimonthly list of its reports that are available to interested institutions. The reports deal with studies of the waters of Iceland. Address inquiries to:

The Library
Hafrannsoknastofnunin
(Marine Research Institute)
Skulagata 4, P.O. Box 390
121 Reykjavik, Iceland

D.L. Mott
ONR London

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

Visitor	Affiliation	Navy Lab./Org. to be Visited
Dr. S.T. Davies	Dept. of Engineering Science Univ. of Warwick Coventry, UK	NRL (9 December 1982)
Dr. S. Forsen	Physical Chemistry Div. Chemical Center Univ. of Lund Sweden	ONR Biosciences Lab. San Diego (13-15 February 1983) George Washington Univ. Medical School, Wash. DC (21 February 1983) ONR (21 February 1983)
Prof. J. Latham	Dept. of Pure & Applied Physics, UMIST, Manchester, UK	NPGS, Monterey (29 Nov-3 Dec 1982) NEPRF, Monterey (29 Nov-3 Dec 1982)
Dr. R.F.C. Mantoura	Inst. for Marine Environmental Research Plymouth, UK	NOSC, San Diego (6-7 Feb 1983) Univ. of Rhode Island (11 Feb 1983) Woods Hole Oceanographic Institution (9/10 Feb 1983)
Dr. H.J. Zimmerman	5100 Aachen-Kornelimünster Korneliusstr. 5 Aachen, FRG	NPG School, Monterey, CA Stanford Univ. (Both January 1983)

ONR COSPONSORED CONFERENCES

ONR London can nominate two registration-free participants in the conferences it supports. Readers who are interested in such participation should contact the Chief Scientist, ONR London, as soon as possible.

OHOLO Biological Conference on Mechanisms of Viral Pathogenesis (From Gene to Pathogen), Zichron Ya'acov, Israel, 20-23 March 1983.

Meeting on Synthetic Low Dimensional Conductors and Superconductors, Les Arcs, Bourg St. Maurice, France, 11-18 December 1982.

7th International Conference on Infrared and Millimeter Waves, Univ. of St. Jerome, Marseille, France, 14-18 February 1983.

Conference on Magnetic Resonance Spectroscopy of Liquid Crystals and Biological Membranes, Leeds, UK, 18-20 April 1983.

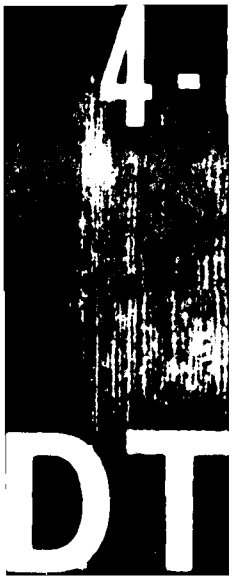
International Conference on Insulating Films on Semiconductors, INFOS 83, Eindhoven, The Netherlands, 11-13 April 1983.

8th European Symposium on Fluorine Chemistry (ESFC-8), Jerusalem, Israel, 21-26 August 1983.

European Specialist Workshop on Active Microwave Semiconductor Devices, Maidenhead, UK, 4-6 May 1983.

SUBJECT INDEX FOR VOLUME 36, ESN ISSUES 1 THROUGH 12, 1982

The articles are listed chronologically under subject heading with title, author, and issue page numbers. Thus, 6:211 indicates issue 6, page 211 of volume 36.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